L. S. CHANDRAKANT

POLYTECHNIC EDUCATION IN INDIA

In developing countries like India, polytechnic education plays a very important part in the training of the much needed technicians who play a special role in industry between the University trained engineers and scientists and skilled workmen. The need for a large number of polytechnics is therefore paramount in India. The author fully emphasises this need and goes on to detail the types of technical courses suitable for polytechnics. Out of his vast experience as Joint Educational Adviser to the Ministry of Education and Youth Services, Government of India, he stresses the reorganisation of polytechnic courses and the development of a suitable curriculum. He has also dealt with the polytechnic student in India and the polytechnic faculty. The last chapter on the engineer-technician ratio is very important.

India needs technicians urgently and hence this sound and thought-provoking book comes at a very opportune time. It needs to be carefully studied not only by all those concerned with technical education in the country, but also by all industrialists who have to depend on

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and Youth Services, Government of India

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a revised edition of the author's book:
TECHNICAL EDUCATION IN INDIA.
In view of the current interest in the
training of technicians and at the request
of the Chairman, Special Committee
on Polytechnics, the material has been
elaborated and brought out as a
separate publication.

The views expressed in this publication
are the author's own and
do not necessarily reflect those of the
Government of India.

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1

Introduction

> "One must learn by doing the thing;
> for though you think you know it
> you have no certainty until you try"
> *Sophocles*

AT ONE end of the manpower spectrum are engineers, scientists and managers; at the other skilled workers and operatives. In between is a group of technical personnel that plays a special role and so merits special attention. This group covers many jobs and bears many position titles: technician supervisor, foreman, overseer, section officer, technical assistant, shift-in-charge. It is responsible for applying technology to a wide range of field operations in production and construction, testing and development, installing and running engineering plant, drafting and designing products, estimating cost, selling and advising customers on the use of engineering or scientific equipment. Often the technician acts as liaison between engineer and skilled craftsman. It is his job to interpret the engineer's plans and designs, to determine the production and construction techniques to be used and to choose the tools and machines best suited to the job. He is also responsible for a host of other semi-professional functions, that he carries out on his own initiative and under the general supervision of a professional engineer or scientist.

It is evident that India needs technicians — all developing countries do. In the short run, we meet critical shortages either by adopting or adapting the expertise of developed countries or by importing capital equipment for industry. However, we cannot make good a shortage of technicians by importing technological equipment for suitable training. In consequence, all developing countries, including India, have to train and develop trained personnel.

CHARACTERISTICS OF TECHNICIAN TRAINING

It follows that we must evolve a coherent system of technical education by which we can train technicians and other types of middle-level personnel needed by industry. Training a technician and developing his professional competence is not a course; it is a long process that takes place partly in a technical institute and partly in industry. The business of a technical institute is to give the prospective technician a sound broad-based knowledge in the theory of his chosen field in engineering. With this, he should be able to understand the basic principles of design, construction and production. He should also be able to communicate his ideas to the expert and to the common man. The curriculum must develop knowledge and mould attitudes to the highest level of proficiency. This education has to be cross-fertilized with practical experience in industry so that the technician-trainee is familiar with working methods and skills relevant to his own field. He has to be made to observe and understand how engineering principles are translated into processes. He has to be as expert on the job in industry as he is expert in the underlying scientific knowledge that has to be applied in the job.

To coordinate theory with practice, to relate technical knowledge with work in industry and to elaborate the complementary functions of technical institutes and industry — all this is the heart of the problem of technician-training. It must be the business of all developing countries to develop a system of technical education that is needed to meet manpower needs so that industry can automatically accept from technical institutes for apprenticeship the material produced by these institutes.

The curriculum for technician-training is not merely an academic exercise. It implies an understanding of such practical aspects as the precise functioning of a technician within industry, the pattern of employment in various types in industry and the relationship between engineers, technicians and skilled workers at various levels.

If our objective is the optimum development of the technician, we must evolve an educational programme that is related to, but differs from the programme that is effective for the production of engineers. It is also related to, but differs from the production of craftsmen. A technician does not need the depth or the range of mathematical or scientific understanding that an engineer requires. What he does need is a knowledge of the same subject with communication skills and mathematical competence at his own level. An educational approach is necessary, but its emphasis is not the same as that implied in a university-collegiate engineering programme. For, a technician needs the practical application of scientific principles more than the development of new design concepts or the extension of existing technical knowledge.

From all this it follows that we have to establish the right functional relationship between engineers and technicians. To do so, we have to plan to improve the status of technicians. We must move engineers to positions of creative responsibility for the research and discovery of new materials and processes and for the development of new engineering designs. We must make use of technicians for the tasks that we believed formerly to be the true realm of the engineer. We have to open up new avenues of professional advancement for the technician.

We have already pointed out that a technician cannot be trained as a craftsman can. The technician stands much closer to the professional levels of engineering than to the trade skills and craft levels of the craftsmen. Only when this is realised, shall we be able to refute the argument that the technician training course is the natural "dumping ground" for those who "cannot make the grade" in university engineering programmes. Both the engineer and the technician are essential to the development of the social and economic professional structure of a modern country. A balance has to be developed between them.

2

Types of Technician Courses

EVERY country must develop its own technical courses in relation to the needs of its industry. There is, therefore, a very wide variety of technician courses possible in a modern world. The structure of courses varies as do their contents and standards. At one end of the spectrum, there are the near-professional courses that demand a sound theoretical knowledge of engineering. At the other end, there are the near-craft courses for technicians who need to master practical skills. In between are courses with varying proportion of theory and craft-content.

FULL-TIME COURSES

Courses naturally vary in complexity. There are the full-time integrated courses that are two to three years long. There are sandwich courses in which a student spends stated periods in industry and then goes back to a technical institute in alternate layers of learning and practice. There are block-release courses; day-release courses; evening courses; and correspondence courses.

Each type of course conducted in a particular country has some bearing on the history of industry in that country. In the USA, technical institute courses grew out of the impact of rapid changes from 1939 onwards. As the frontiers of scientific knowledge were pushed back, the need was increasingly felt to have people who understood how to work in electronic, aeronautical, mechanical and chemical industries. Two-year full-time courses were organised to train engineering technicians. These have spread so widely that at least one in 30 employees in industry in the USA is a technical institute graduate.

In Britain, the sandwich courses represent the joint responsibility of industry and technical institutions. As a large network of the institutions is typical of British industry, part-time courses are offered for various types of technicians and craftsmen upon whom British industry relies. Practical training is provided for four days a week, technical institutes provide the educational content for these courses on one day of each week. The system works admirably for a highly industrialised and heavily populated country where distances are small.

In Australia, New Zealand, the USSR, correspondence courses are popular. The trainees are widely dispersed and part-time and day-release arrangements are not practicable. Sometimes in these countries, the shortcomings of correspondence courses are set off by offering students, courses for a stated period in a technical institution for laboratory experience and direct contact with teachers.

The German system for training practical engineers is unique. These are a highly valued group of middle-level technical personnel. Each candidate who joins an *Ingeneurschule* or *Technicum* can become a practical engineer after he has completed at least a two-year practical course in industry. German industry provides excellent facilities for such apprenticeship training.

In the words of French: "It is vital that a country about to organise (or reorganise) its system of technician education and training should adopt that system (or systems) which is best suited to its particular circumstances, and not simply copy another country's system however well-tried and successful that may be. Only if the two countries 'match-up' will success result from a straight duplication and examples exist where overseas experts who have endeavoured to set up in developing countries a simple image of their own system, have thereby done little good, and perhaps a positive disservice to the countries concerned. An obvious example of a system which is virtually unexportable is the United Kingdom one, which relies heavily upon industry for the training of craftsmen and technicians".

ANALYSIS OF COURSE CONTENT

The main point of technician courses is to give an integrated sequence of instruction in science and mathematics, in technological subject matter and in related shop and laboratory practical work. The analysis given in Tables I and II of a two-year full-time integrated course in electrical engineering and in industrial electronics in USA is an example of this.

H. G. French groups these common contents of the technical curricula courses into:

(a) Technical Education (Theory)
(b) Technical Education (Practical)
(c) Technology (Theory)
(d) Technology (Practical)
(e) General Education.

French here includes under Technical Education (Theory) science and mathematics and engineering drawing that constitute the theoretical basis for engineering techniques. This basis equips the candidate with the knowledge to appreciate and adapt himself to new developments. Technical Education (Practical) includes laboratory and experimental work.

Technology (Theory) covers theory relating to equipment with which the technician is concerned and to the specific techniques that he has to use. Technology (Practical) means the skills that the technician needs to do his job. They include basic manual skills similar to those of a craftsman, but they may also involve skilled measurements that have to be made and various types of tests. This work implies judgement and the intelligent application of theory.

The elements of a technician course are not self-contained and independent but form integral parts of a conceptual whole. The lines of demarcation are vague. The basic principles and their practical application are increasingly indivisible. In the last

TABLE I

ANALYSIS OF ELECTRICAL ENGINEERING TECHNOLOGY CURRICULUM

TOTAL CONTACT HOURS

Curriculum	Major technical speciality	Allied technical speciality	Mathematics	Lab.	"General" subjects (English and communications)	Other
1	2	3	4	5	6	7
Electrical Engineering Technology	241	231	252	861	55	73
1. Chemistry	—	63	—	84	—	—
2. Electricity	178	—	—	126	—	—
3. Engineering Drawing	—	21	—	147	—	—
4. Electronics	63	—	—	42	—	—
5. Engineering Lab.	—	—	—	84	—	—
6. English and Technical Reading	—	—	—	—	55	—
7. Mathematics	—	—	252	—	—	—
8. Mechanics	—	63	—	42	—	—
9. Metal Laboratory	—	—	—	189	—	—
10. Physics	—	—	—	147	—	—
11. Psychology	—	—	—	—	—	21
12. Natural History	—	—	—	—	—	10
13. Industrial Supervision	—	—	—	—	—	42
14. Strength of Materials	—	84	—	—	—	—

Total contact hours: Class 852, Lab. Shop 0—
Total 1713 (+ coop work, 1920).

TABLE II

ANALYSIS OF CURRICULUM IN INDUSTRIAL ELECTRONICS

TOTAL CONTACT HOURS

Curriculum	Major technical speciality	Allied technical speciality	Mathematics	Lab.	"General" subjects (English and communications)
1	2	3	4	5	6
Industrial Electronics	665	515	170	990	100
1. Physics	—	100	—	80	
2. Mathematics	—	—	170	110	
3. Basic Elec. A-C & D-C	150	—	—	90	
4. Electrical Instruments & Measurements	115	—	—	95	
5. Circuit Drawing & Layout	—	10	—	30	
6. Mechanical Drawing	—	10	—	30	
7. Technical Report Writing	—	—	—	60	100
8. Vacuum-tube Principles Circuits	255	—	—	145	
9. Modulation Principles	45	—	—	35	
10. Field Theory	45	—	—	35	
11. Complex Waveform Analysis	45	—	—	35	
12. Automatic controls	50	50	—	30	
13. Electronic Relays	—	45	—	35	
14. Transducers and special Devices	—	50	—	30	
15. Process Instruments	—	250	—	150	

Total contact hours: Class 1440, Lab. 990, Shop 0 — Total 2430.

analysis, the usefulness of a technician course may be judged by how well the technician is trained to do a practical job of work. His command of theory is reflected in his practice.

Finally, every technician course needs a sub-structure of general education that will equip the technician with the ability to communicate and make him aware of the social and economic framework within which he must function. He must be able to express himself verbally as well as mathematically and scientifically. He must interpret the designs of engineers and instruct those who work for him. He must have some grasp of the language in which he expresses himself so that he may understand and be clearly understood. Many technicians exercise supervisory functions that demand an understanding of human relations, labour laws and organisation of industry. To perform these functions well, technicians must grasp their professional obligation to society. The purpose of the sub-structure of general education is to help a man to know his place within the social group to which he belongs.

The proportion of the five elements that constitute technician training may vary from one course to another depending on whether the course is near-professional or near-craft. The first has a high proportion of technical and technology theory; the second a high proportion of operative skills. As an example, H. G. French analyses a near-professional course in the following three-year full-time technician course:

Technical Education (Theory)	37.8 per cent	Theory 54.5 per cent Practical 33.3 per cent General 12.2 per cent
Technical Education (Practical)	22.2 per cent	
Technology (Theory)	16.7 per cent	
Technology (Practical)	11.1 per cent	
General Education	12.2 per cent	

SUBJECT FIELDS OF TECHNICIAN COURSES

The courses offered to technicians may vary from broad subject-fields in engineering to narrow specialised branches of each field. Below is a representative range of such subjects:

Civil Engineering:

Civil Engineering (general); structural engineering; construction; concrete technology; land surveying, plumping designs and quantities; drafting; traffic engineering; materials; painting and decorating; earth moving equipment.

Electrical Engineering:

Electric Engineering (general); installation; illumination; technical sales.

Mechanical Engineering:

Mechanical engineering (general) draftsmanship; marine engineering; heavy duty equipment; power plant; machine shop engineering; toolmaking.

All that has been said so far explain why educationists have begun to worry about the proliferation and fragmentation of technician courses. Full-time integrated courses are the basic pattern in most countries. They can be provided without the limitation of employment opportunities in local industry. However, they have some disadvantages such as: (a) the practical technology so essential for a technician is on a much smaller scale than can be provided in industry; (b) the industrial atmosphere is lacking at institutions that tend to operate in an area removed from technological change.

Wherever full-time courses are entirely institution-based, these defects have to be corrected by simulating practical work in industrial conditions. Practical training in industry helps. Even more effective is a full-fledged programme of apprenticeship-training in industry for a year or two after institutional studies are over. Several countries provide industrial apprenticeship programmes on an optional basis at the post-institutional stage.

SANDWICH AND BLOCK-RELEASE COURSES

Sandwich courses, so popular in the United Kingdom, provide for the active participation of industry. The normal arrangement is called "the-half-and-half," i.e., six months of the year in an institute, and the remaining six in a cooperating industry. Students may be either industry or college-based. If the former, they are paid a salary by the firm that is responsible for industrial training. If the latter, maintenance grants are paid by local educational authorities. A large proportion of students are works-based. The success of the sandwich system depends on relations between institutions and industrial establishments.

Block-release from industry is a comparatively new experiment, in which students attend the college full-time for periods varying from two weeks to four months. The most popular arrangement is for a full-time attendance of 12 weeks. Sandwich courses require over 18 weeks continuous full-time attendance at an institute. Anything less, which is full-time, is labelled block-release.

The arguments for block-release are continuity and intensity of study that enable teachers and students to know one another. There is also more time to integrate languages and liberal studies with technical studies. Firms that support block-release make for effective useful training because they can be used every day all the year round. This provides for a bigger intake of apprentices.

The educational argument against block-release is that the lapse of time in between blocks of attendance at college results in students forgetting what they have learnt. Theory and training could get out of gear and the pauses result in some loss of skill and retardation of practical training. These arguments also apply to sandwich courses but they are being corrected in many ways. For instance, students are required to attend on one or two evenings per week or to continue day-release between each period of block-release. The additional time is given to tutorial work in preference to class teaching.

Part-time courses aim at giving educational content to the future technician while he is picking up technology practice on-the-job in factory. However, since these courses place a severe limitation on the amount of time a student can give, they tend to restrict general and technical education content. A major part of the professional development in this arrangement must take place in industry. Today, most countries prefer full-time integrated courses to sandwich courses. A technician who has to face technological changes must be trained on the sub-structure of a strong educational base. This implies stiff and thorough instruction in the fundamentals of science, mathematics and technical sciences. A competent technician must in effect be an educated man.

Correspondence courses, now well established in Australia, New Zealand and the USSR are useful for students who are widely dispersed and to whom block-release or day-release is not practicable. The chief shortcoming of correspondence courses is the lack of face-to-face contact between teacher and taught. In several countries, this is corrected by requiring correspondence students to spend a certain amount of time in an institution for laboratory experience and other types of instruction.

3

Polytechnics in India

SINCE 1947 when India became independent, there has been a phenomenal expansion of technical education at the polytechnic Diploma level. In 1947, only 53 institutions conducted Diploma Courses and they admitted only 3670 students each year. The number of Diploma-holders trained were less than 1500 a year. Today, we have about 279 institutions capable of admitting about 50,000 students a year. The number of Diploma-holders trained each year has jumped to about 23,500. The total financial outlay on these institutions so far exceeds a billion rupees for their campuses, buildings (including hostels), equipment and other capital items. Their annual budget for maintenance expenditure is over 100 million rupees. Today, over 2,00,000 diploma-holders who have graduated from these polytechnics work in various departments of public life. The present student-enrolment is about 100,000; the faculty consists of over 10,000 teachers.

This is the magnitude of our technical education enterprise at the middle level.

HISTORICAL BACKGROUND

The origin of Polytechnic education in India is lost in the dim past of the country. Between 1830 and 1850, four engineering schools were started as institutions attached to engineering colleges at Madras, Calcutta, Poona and Roorkee to train "Upper and Lower Subordinates" (Overseers, Sub-Overseers and Draughtsmen) for the Public Works Departments, Local Funds, Municipalities, etc., of the then Provincial Governments. Sir A. P. MacDonnel, then Home Secretary to the Government of India, in a memorable report on "Technical Education in India" in 1886 described the nature and scope of training given at these engineering schools as follows:

Madras Presidency

> "The Madras Civil Engineering College consists of two departments—the Collegiate and the School Departments. After a prolonged discussion, the College was reorganised last year. The object of the Collegiate Department (which was established in 1862) is to train students who have received a liberal education, for employment as Engineers or for the degree of B.C.E. in the Madras University. There is also a Mechanical Engineering class. One engineer's appointment in Government service is guaranteed annually to the College; but still the College is quite local in its effects, and the Public Works Department of the Government of India knows very little about its results. In all Departments the course seems to be wholly theoretical which is a serious defect.
>
> The School Department trains students for the subordinate engineering posts under the Public Works Department, Local Funds, Municipalities and there are also classes for surveyors and draftsmen. The upper subordinate (i.e. School) students have a year's practical training after leaving the School before appointment to the public service.
>
> The average number of students on the roll of the Collegiate Department last year was 19 and in the School Department 106. These numbers are an improvement on preceding years, and the Report for 1883-84 stated that applications for admission to the Collegiate Department are more numerous

than the accommodation and teaching capacity of the Institution can meet. The popularity of the Collegiate is said to be increasing, while students of merit are reported to find no difficulty in getting employment. The great want seems to be facilities for practical training, which, having regard to the existence in Madras of large railway termini and workshops ought not to be insurmountable".

"The only Engineering School in the Presidency is the Junior Department of the Civil Engineering College, to which reference has already been made under the head of University Education. The course of instruction comprises elementary mathematics, engineering surveying, drawing and estimating, bricklaying, and the Madras vernacular languages. One scholarship of Rs. 13 per mensem tenable for two years, five scholarships of Rs. 15 and ten of Rs. 10 each tenable for one year are attached to the school, and, besides these, ten studentships of Rs. 10 each per mensem are available for European non-commissioned officers and soldiers who join the school. The institution derives no revenue except from the State. The instruction conveyed in the school is believed to be too theoretical, facilities for practical work being deficient. Still, it is stated, that passed students of the school find no difficulty in getting remunerative employment either under Government of Local Boards or on Railways, and this fact tends to make the school popular and applicants for admission numerous. It is therefore a matter for regret that owing to insufficient accommodation, all applicants for admission to the school cannot be received. An excellent feature of the organisation seems to be a system of examination by which candidates, not being students of the school, appear and obtain on passing examinations certificates of competency as draftsmen and surveyors".

Bombay Presidency

"The Poona College of Science, formerly the Poona Civil Engineering College, arose out of a school established in Poona in 1854 by Government for the purpose of educating subordinates for the Public Works Department. The College is divided into four departments:

(a) Matriculated students studying for University degrees in civil engineering;
(b) Matriculated students studying scientific agriculture in the College and the farm attached to it;
(c) Matriculated students who study Forestry;
(d) Students studying in the College and attached to workshops with the object of becoming overseers, etc.

Attached to the Engineering College are extensive workshops, which have from time to time been extended from the profits made on works executed in them. In these workshops practical instruction is conveyed and work of various kinds executed for Government and the public. The University of Bombay requires candidates for the L.C.E. degree to perform manual work before the examiners; and this secures for the students in the College a course of practical training noticed as wanting in Madras. The students in the lower or School classes, who become overseers, etc., have to go through a workshop course of from 2 to 4 years' duration, and it is by them that the work in the shops is chiefly executed. The attending (attendance) at the Engineering College last year was 103, and the Engineering School 67".

Bengal Presidency

"At the Seebpore College near Calcutta candidates for the degree of Civil Engineering have to go through a four years' course of theoretical training with which some practical work is combined. During this period they spend three hours daily during term in the carpenter's and pattern shop, smithy, foundry, or fitting shop. Part of the last year's course consists of practical brick-making in the Government brick-fields at Akra; and of practical work in stone masonry, brick-laying, managing workmen, and keeping accounts. Those who are selected for Government employment have to spend another year in the Department without pay as probationers, but they are distinguished students, who are generally in the receipt of Government scholarship.

Besides the collegiate course described above, there are courses for Mechanical Engineers, Civil Overseers, and Mechanical Overseers. These courses follow generally the outlines of the course for L.C.E. with appropriate modifications.

Last year the number on the rolls of the College Department was 42; and on the rolls of the Subordinate or Apprentice class 107. The Principal of the College reports that considerable aparthy still prevails among the students; but, on the other hand, it is stated that those who have passed through the College or School find little difficulty in getting employment".

North-Western Provinces and Oudh

"The Thomason Civil Engineering College at Roorkee, founded in 1847 by Mr. Thomason, then Lieutenant-Governor of the North-Western Provinces, and affiliated to the Calcutta University in 1864, was first designed to supply the Department of Public Works and Survey Departments with Assistant Engineers, Overseers, and Sub-Overseers. It is now, however, open to the public. The College contains three classes: (a) Engineering Class; (b) Upper Subordinate Class; (c) Lower Subordinate Class. The Engineer Class is open to Europeans and Statutory Natives of India, who have passed the Entrance Examination of the University or other similar test. The students go through a two-years' theoretical course, during which they receive practical instruction in surveying and preparing projects. After the two years' course is over, students are eligible for appointment as Engineer Apprentices, so far as vacancies are available, and are supposed to undergo a practical training. After being favourably reported on, selected students are appointed Assistant Engineers in the Department of Public Works, four or five appointments of the sort in alternate years being attached to the College. It is stated that some very valuable Engineers have been turned out of this College. Their instruction in surveying is most thorough. They exhibit great skill in managing native workmen and in applying the resources of the country.

The Upper Subordinate Class also consists of students who have qualified by a preliminary literary test. They have two years' theoretical course in the College, and afterwards one year's practical training. This class includes non-commis-

> sioned officers from British regiments, as well as "Natives" of India.
>
> The Lower Subordinate Class are all Natives of India by descent, and a qualifying preliminary education is necessary for admission. Soldiers of the Native Army desirous of learning so much surveying as suffices for reconnoitring purposes are received in this class without previous qualifying education. Generally the courses of study in the principal classes are varied, but include Mathematics, Civil Engineering, Surveying, Drawing and Urdu, the extent read being of course different in each class. Besides, the Engineer Class learn experimental science and photography. The College also holds examinations and grants certificates of qualification as Sub-Engineer, Overseer, and Examiner of Accounts, Department of Public Works, to all candidates who present themselves, under certain rules. Several valuable stipends and studentships are attached to the College; and the numbers attending the various classes last year were:-
>
> | | |
> |---|---|
> | Engineering Class | 21 |
> | Upper Subordinate Class | 78 |
> | Lower Subordinate Class | 43 |
>
> There are no Workshops attached to the College; but in the neighbourhood are situated the well known Roorkee Workshops belonging to the Local Government. The students visit these; but they do not perform manual labour there, as at Seepur and Poona. Their visits, therefore, are practically of little value. It is understood that there is some idea of disposing of these workshops as unnecessary for Government purposes. But preferably it is submitted they should be made over to the College, and a system of practical training added to the theoretical course".

According to this report, the importance of training middle level technician had been realised in India as far back as 1830, though at that time modern engineering, as we know it today, was still in its formative stage. Efforts were made by the then Provincial Governments to train these personnel to help the professional engineer on civil engineering works. The duration of the courses varied from one to three years depending upon whether "Upper Subordinates" or "Lower Subordinates" were being trained. Sir MacDonnel also explains briefly the contents of the courses — that they included instruction in mathematics, engineering surveying, drawing and estimating, and practical work in civil engineering construction. Though the engineering schools trained the students as Overseers, Sub-Overseers and Surveyors, the courses were generally designated as "Upper Subordinate" and "Lower Subordinate" classes, since only engineers were eligible for the "Gazetted Services" (also called Superior Services) and all the rest for "Subordinate Services" under Government. Since then, engineering has developed in a big way, but the hierarchical structure of professional employment in Government has changed little. Even today, only Graduates in Engineering are accepted for superior posts and services and diploma-holders from polytechnics for subordinate posts. A sad commentary on the status of Technicians after a century!

As the demand for "Upper and Lower Subordinates" grew with the expansion of engineering activity in India, more engineering schools were established in various parts of the country. As the types of engineering activity were diversified, the schools added courses in mechanical and electrical engineering. The schools also became more popular among students, because of the readily available employment opportunities in their respective regions. In course of time all engineering schools, many of them established as separate and independent institutions from engineering colleges came to occupy a definite position in the technical education system of our country. They also came to be called polytechnics since they offered courses in all three basic branches of engineering. Some included courses in textiles technology, chemical technology, radio engineering, fisheries technology and other fields in response to demand for technical personnel from local industry.

As polytechnics multiplied, the duration, content and standard of the courses conducted by them varied widely from institution to institution. There were courses of one, two, three and four years' duration. While science, mathematics and technology (theory) were integrated in some courses, the curriculum of others was scrappy and uncoordinated. Examinations were held by different authorities in different provinces — Departments of Education, Public Works Departments, Industries Departments and so on — depending upon which particular Department was administratively in charge of polytechnics in a Province. The students were awarded Diplomas in Engineering at some institutions, and at others, certificates. Instructional facilities like accommodation, equipment and teaching staff also differed widely and those differences in turn were reflected in differing academic standards of institutions.

RE-ORGANISATION OF POLYTECHNICS

When India became independent in 1947, the Government of India recognised the importance of technical manpower for the economic development of the country and decided to expand facilities for technical education and training in a big way. Improvement and coordination of standards of polytechnic education became important and urgent. The All-India Council for Technical Education with the assistance of its Boards of Studies in Engineering and Metallurgy, Chemical Engineering and Chemical Technology, Textiles Technology and in other subject-fields reviewed in 1948 the state polytechnic education in the country and initiated a comprehensive programme for the re-organisation and development of polytechnics. The programme included revision of the syllabus and curriculum of courses, and maintenance of uniform standards; provision of adequate instructional facilities for conducting the courses; and adoption of a uniform scheme of examinations for all polytechnics. The Boards also laid down in detail the accommodation needed for class-rooms, laboratories, workshops, etc., in a polytechnic for different courses, lists of laboratory and workshop equipment that polytechnics should have and teaching and other staff that require to be appointed to conduct the courses. The Regional Committees of the All-India Council sent Visiting Committees of experts to inspect each polytechnic and to prepare a scheme for its improvement and development according to these standards. On the basis of the recommendations of the Regional Committees, the Central Government gave grants-in-aid to the institutions to reorganise their courses and improve instructional facilities. Every new polytechnic set up since 1950 followed the standards laid down by the All-India Council for Technical Education.

Today, a polytechnic in India represents a technical institution at the middle level which conducts full-time Diploma Courses in Civil, Mechanical and Electrical Engineering. The duration of the courses is three years and the minimum educational requirement for admission is the Matric or Secondary School Certificate with Physics, Chemistry and Mathematics as the main subjects. Some polytechnics also conduct Diploma Courses in Radio Engineering, Textiles Technology, Leather Technology, Ceramic Technology. All polytechnics, except two or three institutions that are under the control of universities, are affiliated to their respective State Boards of Technical Education. The State Boards prescribe the Diploma Courses to be conducted by their polytechnics, inspect the institutions to ensure maintenance of adequate instructional facilities, conduct examinations and award Diplomas. More than half of our polytechnics are administered and maintained by State Governments. The rest are managed by private agencies with regular grants-in-aid from their respective State Governments. For the development of all institutions according to correct standards, the Central Government gives financial assistance under the Five-Year Plans.

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Polytechnic Curriculum

THE three-year full-time Diploma courses conducted by our polytechnics are patterned after the National Certificate Courses which have been evolved by the Boards of Studies of the All-India Council for Technical Education as a model for polytechnic education. An analysis of the curriculum of the National Certificate Courses in Civil, Mechanical and Electrical Engineering is given in Tables III-A, B and C and IV between pages 23-31.

MAIN FEATURES OF POLYTECHNIC CURRICULUM

On this analysis, the main features of our polytechnic diploma courses are:

(a) The courses are wholly institution-based.

(b) The curriculum is broadly structured for each branch of engineering to train a generalist-technician in that branch.

(c) The curriculum is the same for all branches in the first year of the diploma course so as to give a common foundation of science and mathematics, workshop training, drawing and mechanics. The common foundation is extended fully to the second year of the courses in mechanical and electrical engineering and partly in civil engineering. The third year is devoted wholly to the major branch of engineering in which the final diploma is awarded.

(d) The total number of contact hours is 3456 which include theory and practical work in laboratories, workshops, field and drawing office. The overall proportion between theory and practical work is 37:63 per cent. The proportion between major technical speciality and the rest of the curriculum is 2:1 per cent for civil engineering and 3:1 per cent for mechanical and electrical engineering.

At first the All-India Council for Technical Education visualised that every polytechnic student should complete a two-year apprenticeship in industry or an equivalent period of on-the-job training after institutional studies to be eligible for the award of the diploma. This apprenticeship or practical training was considered essential by the All-India Council to equip the prospective technician with adequate experience for gainful employment at the middle level. Later, when industrial establishments started recruiting candidates immediately after their diploma examination and training them for specific jobs the All-India Council waived the requirement of a two-year apprenticeship. Nevertheless, a large number of polytechnic diploma-holders join the Central Governments' scheme of practical training each year to equip themselves with industrial experience.

CRITICISM OF POLYTECHNIC CURRICULUM

Though nearly 200,000 polytechnic diploma-holders are at present employed in industry and other organisations and contribute to the economic development of our country, polytechnic education has in recent years come in for much criticism. Some of the criticisms are vague; the rest fall into following categories:

(a) Polytechnic courses are essentially theoretical in character and their practical content is inadequate.

(b) Polytechnic courses are a poor imitation of the university degree courses in engineering.

(c) Polytechnic courses conducted at present are in the broad

TABLE III-A

ANALYSIS OF CURRICULUM OF NATIONAL CERTIFICATE COURSE IN CIVIL ENGINEERING

	Major Technical Speciality	Allied Technical Speciality	Mathematics	General Education	Shop or Field work	Laboratory or Drawing
Civil Engineering	696	360	120	120	1296	864
1. Mathematics	—	—	120	—	—	—
2. Mechanics	—	96	—	—	—	24
3. General Science	—	120	—	—	—	96
4. Drawing	48	—	—	—	—	576
5. Workshop	—	—	—	—	384	—
6. Languages	—	—	—	86	—	—
7. Applied Mechanics	240	—	—	—	—	48
8. Hydraulics	—	48	—	—	—	24
9. Mechanical Engineering	—	24	—	—	—	24

10. Electrical Engineering	—	24	—	—	—	24
11. Civil Engineering	24	—	—	—	384	24
12. Surveying	72	—	—	—	528	—
13. Engineering Materials	—	48	—	—	—	24
14. Labour Relations & Civics	—	—	—	34	—	—
15. Details of Construction	48	—	—	—	—	—
16. Estimating & Costing	72	—	—	—	—	—
17. Public Health Engineering & Irrigation	72	—	—	—	—	—
18. Roads, Railways and Bridges	72	—	—	—	—	—
19. Overseers' Duties	48	—	—	—	—	—
Total:- 3456	696	360	120	120	1296	864

TABLE III-B

ANALYSIS OF CURRICULUM OF NATIONAL CERTIFICATE COURSE IN MECHANICAL ENGINEERING

TOTAL CONTACT HOURS

	Major Technical Speciality	Allied Technical Speciality	Mathematics	General Education	Shop or Field work	Laboratory or Drawing
Mechanical Engineering	592	408	120	120	1232	984
1. Mathematics	—	—	120	—	—	—
2. Mechanics	—	96	—	—	—	24
3. General Science	—	120	—	—	—	96
4. Drawing	72	—	—	—	—	576
5. Workshop	16	—	—	—	1136	—
6. Languages	—	—	—	86	—	—
7. Applied Mechanics	192	—	—	—	—	48
8. Hydraulics	—	48	—	—	—	24
9. Mechanical Engineering	24	—	—	—	—	24

10. Electrical Engineering	—	24	—	—	—	24
11. Civil Engineering	—	24	—	—	—	24
12. Surveying	—	48	—	—	48	—
13. Engineering Materials	—	48	—	—	—	24
14. Labour Relations and Civics	—	—	—	34	—	—
15. Estimating & Costing	96	—	—	—	—	—
16. Heat Engines	72	—	—	—	—	72
17. Workshop Technology	48	—	—	—	48	—
18. Electrical Technology	24	—	—	—	—	48
19. Workshop Organisation and Foremanship	24	—	—	—	—	—
20. Accounts	24	—				
Total: 3456	592	408	120	120	1232	984

Table III-C

ANALYSIS OF CURRICULUM OF NATIONAL CERTIFICATE COURSE IN ELECTRICAL ENGINEERING

TOTAL CONTACT HOURS

	Major Technical Speciality	Allied Technical Speciality	Mathematics	General Education	Shop or Field work	Laboratory or Drawing
Electrical Engineering	640	408	120	120	1184	984
1. Mathematics	—	—	120	—	—	—
2. Mechanics	—	96	—	—	—	24
3. General Science	—	120	—	—	—	96
4. Drawing	72	—	—	—	—	576
5. Workshop	16	—	—	—	1112	—
6. Languages	—	—	—	86	—	—
7. Applied Mechanics	192	—	—	—	—	48
8. Hydraulics	—	48	—	—	—	24
9. Mechanical Engineering	—	24	—	—	—	24

10. Electrical Engineering	24	—	—	—	—	24
11. Civil Engineering	—	24	—	—	—	24
12. Surveying	—	48	—	—	48	—
13. Engineering Materials	—	48	—	—	—	24
14. Labour Relations and Civics	—	—	—	34	—	—
15. Estimating & Costing	96	—	—	—	—	—
16. Workshop Technology	24	—	—	—	24	—
17. Continuous Current Engineering	60	—	—	—	—	48
18. Alternating Current Engineering	60	—	—	—	—	48
19. Electric Power	48	—	—	—	—	24
20. Workshop Organisation and Foremanship	24	—	—	—	—	—
21. Accounts	24	—	—	—	—	—
Total: 3456	640	408	120	120	1184	984

TABLE IV

TOTAL CONTACT HOURS

	Civil Engineering		Mechanical Engineering		Electrical Engineering	
	Hours	Percentage	Hours	Percentage	Hours	Percentage
1. Major Technical Speciality	2256	65.5	2544	73.9	2544	73.9
(i) Theory	696	20.4	592	17.4	640	18.8
(ii) Practical	1560	45.1	1952	56.5	1904	55.1
2. Allied Technical Speciality	960	27.8	672	19.4	672	19.4
(i) Theory	360	10.4	408	11.8	408	11.8
(ii) Practical	600	17.4	264	7.6	264	7.6
3. Mathematics	120	3.5	120	3.5	120	3.5
4. General Education	120	3.2	120	3.2	120	3.2
Total:	3456	100	3456	100	3456	100

> fields of engineering and no training is given in the many specialised branches of a major engineering field, in which technicians are needed by industry.

It is important for us to examine these criticisms in detail before we can suggest the lines along which polytechnic education must be reorganised. The criticism that the polytechnic courses are essentially theoretical is not valid as our earlier analysis shows. No curriculum that restricts theory to about one-third of the total contact hours can be described as a predominantly theoretical course. The structure of our polytechnic curriculum, the relative proportion in which the different subjects constituting the curriculum are designed to be taught and all other aspects compare favourably with similar whole-time integrated curricula of technician courses in advanced countries.

Why then is this criticism levelled against our polytechnic diploma courses? First because our polytechnic courses being wholly institution-based are not backed up by adequate practical experience in industry and this is vital to produce a finished technician fit to enter upon his professional responsibilities in an industrial organisation. This inadequacy is not integral to the polytechnic curriculum but is mainly due to the fact that few of our industrial and other technical organisations have set up a first-rate system of apprenticeship to complement polytechnic education. More: they demand that our polytechnics should produce technicians equipped with adequate practical experience. It is inconceivable that any technical institution anywhere in the world can fill this bill without the cooperation of industry. The Sandwich and Block Release courses in Britain are typical examples of the close cooperation that has been established between industry and technical institutions, one complementing the role of another and both sharing the responsibility for training technicians. In Germany the pre-institutional apprenticeship exemplifies the participation of industry in that country. In other advanced countries like the United States organised programmes of apprenticeship for students after their institutional studies for conditioning them for gainful employment are a normal feature of industry's responsibility. It is, therefore, clear that unless technician-development in our country is visualised as an integrated process which must take place partly in polytechnics and partly in industry and the two halves matched closely, there is no way of improving the present system of technical education. The process is complete only when industry shares responsibility with polytechnics.

Second, the technician functions as we said earlier constitute a broad spectrum. At one end of the spectrum are the near-professional functions which demand a sound theoretical knowledge of engineering. At the other end, the functions demand of the technician mastery of practical skills of the craft type. In between, the technician functions have varying proportions of professional engineering and craft-type activities. No single course like that offered by our polytechnics can possibly produce technicians capable of performing all these wide ranging functions. When therefore our industry criticises polytechnic diploma courses as being lacking in practical content it is in effect demanding mainly technicians who possess mastery of manual skills of the craftsman type. It overlooks the aims and objects of the polytechnics courses, namely, to train technicians for non-professional duties which demand the application of known technology to field operations in production and construction, testing and development, installing and running plants, drafting and designing products, estimating costs, interpreting engineers' plans and designs and determining the types of production or construction techniques to be adopted. Only when diploma-holders, after the relevant practical training are employed and tested for these engineering duties can an objective assessment be made of the inadequacies of the polytechnic courses. There is evidence to show that where industrial organisations have employed diploma-holders in this way they have hardly criticised the system of polytechnic education and are, in fact, satisfied with products of the system. The pre-employment apprenticeship programmes for graduate engineers and diploma-holders organised by large public and private sector enterprises and through which the correct type of technicians are trained are cases in point. We must also remember that of the total stock of technical manpower in employment in 1969 which is estimated at about 300,000, at least 200,000 are diploma-holders from our polytechnics. No one can dispute the fact that these diploma-holders are engaged in productive occupations in which their education and training are found useful by their employers.

Undoubtedly, our industry also needs technicians with a mastery of practical skills of the craftsman type for supervisory positions like foreman in charge of production or construction work. Such technicians can be developed only on a craft base and for this purpose, a separate educational process must be designed and incorporated into the structure of polytechnics. This educational process must bridge the present sad gap between the training of craftsmen and their later development as technicians. The structure of our polytechnics must have several facets to meet the needs of industry for different types of technicians.

POLYTECHNIC VIS-A-VIS ENGINEERING COLLEGE COURSES

The second criticism that our polytechnic courses are a poor imitation of university degree courses in engineering has been levelled at them mainly by academicians in engineering colleges. This betrays a lack of understanding of the wide range of duties and responsibilities of technicians in industry and also of the structure of polytechnic courses. The non-professional duties of polytechnicians demand of them the ability to apply known technology to field operations in production or construction work in design and drafting office, in testing and development, in estimating costs and in interpreting engineers' plans and designs. To equip the technician with the necessary professional, technical competence the course must give him a sound, broad based engineering education to enable him to understand the basic principles underlying design, production and construction processes and to communicate his ideas scientifically, mathematically and verbally. The technician course must therefore be intimately related to the same areas of knowledge as come under the purview of the engineer, but differ significantly from an engineering degree course. As indicated earlier, the difference is that the technician does not need either the depth of the mathematical and scientific understanding of the principles of engineering or the analytic derivation of those principles. What he does need is an understanding of the practical application of those principles rather than the development of new design concepts or the extension of existing knowledge. For unambiguous results, this demands an educational approach that is academically rigorous and technical in preference to a skill-proficiency programme that is effective in training a craftsman.

If the structure of our polytechnic courses reflects these basic principles of technician-development and is comparable in quality and general level to the collegiate engineering programme, it cannot be dubbed a "poor imitation of our degree courses". We must remember that the collegiate degree programme provides about 60-64 per cent of the curricula contact time for theory as against 36-40 per cent in the polytechnic diploma courses. This big difference in the level of theory between the two courses refutes the criticism.

DIVERSIFICATION OF DIPLOMA COURSES

The third criticism is that our polytechnic diploma courses are conducted in the broad fields of civil, mechanical and electrical engineering and do not offer training in the many specialised branches in which technicians are needed by industry. It is time that the diploma courses are diversified into different technician specialities. The main reason for this is that the pattern of employment of technicians in the major sectors of our national economy has not so far demanded specialist technicians but generalists who, in the course of their professional life, can cover a wide range of activities. Take civil engineering which accounts for a substantial part of our engineering activity. The main employers of our technical personnel in this field are the Public Works Departments of State and Central Government. Till some years ago, in several states, the Public Works Departments were generally in charge of all civil engineering construction, buildings, roads, highways, bridges, irrigation works, dams and so on. A technician employed in these organisations as an overseer or in an equivalent supervisory position was required to have a broad based engineering education covering all these different types of constructional activity. His main duties included design-drafting, estimating and planning, surveying, supervision of construction, inspection and maintenance of works. Once he entered the Department, he moved from one type of civil engineering work to another — from buildings to highways and bridges to irrigation and hydraulic structures to public health engineering. He was not expected to be a specialist in any one of these works and as he moved up the professional ladder, his supervisory responsibility extended over the whole field of civil engineering design, construction and maintenance. Accordingly, the structure of polytechnic diploma courses has had to reflect a general and broad-based approach to the whole field of civil engineering and not to give specialised training in any one particular type of constructional activity. If they had not done so, the polytechnics would have been out-of-step with the pattern of employment in the Public Works Departments and would perhaps have rendered their diploma-holders unemployable because of their specialisation. Unless therefore the pattern of employment in Government Departments in charge of civil engineering works, and recruitment procedures followed by the Departments and avenues of professional advancement for technical personnel undergo a radical change *vis-a-vis* engineering specialities, it is not desirable for polytechnics to diversify their diploma courses into functional specialities of civil engineering. In a developing technology, a generalist type of technician or engineer is less exposed to uncertainties of gainful employment since with experience or training on the job, he can adapt himself to a wide range of professional activity.

Only in recent years have the State and Central Governments divided the omnibus responsibilities of their Public Works Departments into major civil engineering activities and established separate departments for buildings, highways and bridges, irrigation and public health engineering. As a corollary the stage has come when our polytechnics can restructure their diploma courses to provide specialised training for technicians in these civil engineering specialities. It is, however, important that the specialised training should be organised on as broad a base as possible to ensure the employability of the diploma-holder as a generalist technician wherever such opportunities are available. This demands a judicious combination of general civil engineering training and specialisation in a chosen branch.

All that has been said so far about civil engineering applies equally to electrical engineering. In this field, too, the major employers are Electricity Departments of State Governments or other authorities in charge of power generation, transmission and distribution. The spectrum of professional duties of an electrical technician includes installation, operation and maintenance of power generating plants, transmission and distribution of power, design-drafting, inspection and testing and load survey. This broad spectrum of professional work demands a broad based generalist type of education for a technician who has to work in our electrical undertakings. The polytechnic diploma courses as they are structured at present offer the required generalist type of education. Only in recent years have we developed an electrical manufacturing industry, but according to available reports industry has perferred to recruit diploma-holders with a broad based education in electrical engineering and to train them in the works for specific manufacturing, testing and drafting and other functions. The different technician specialities in this field that can be incorporated in the structure of diploma courses need to be identified in consultation with industry.

Only in mechanical engineering, particularly manufacturing industry, does the pattern of employment seem to demand technicians trained in particular engineering specialities. Our engineering industry has expanded and is expanding on a big scale to include such important items as heavy machine building, tractors and earth-moving equipment, automobiles, pumps and pump sets, heavy electrical equipment, structurals, foundry and forgings, equipment for processing industries and so on. Many manufacturing units are designing their own products, developing production know-how, testing and standardising the products produced and extending servicing facilities to customers. For these complex processes, manufacturing enterprises have set up separate departments for designing products, manufacturing, testing and servicing functions. As functions are departmental the manpower structure of the enterprises tends to be oriented towards specialisation in the relevant field of engineering. As a corollary, in recruiting engineers and technicians to their different departments the enterprises prefer those who have had specialised training in those fields in which the Departments are engaged. An engineer or technician entering a particular department of an industrial enterprise generally stays in that department throughout his professional career and advances there professionally with experience. Rarely does he cross over to another functional department. His professional work is identified with the speciality of the department for which he was initially recruited. If the structure of our polytechnic courses can be matched against this pattern of employment in industry and made to provide in the diploma courses for specialised training in those fields that are functionally related to the different aspects of the work of an industrial enterprise, we could establish close coordination between our polytechnics and the needs of industry for specialist technicians. This implies careful analysis of the activity of industrial enterprises, manpower formations in the enterprises, job positions available and a precise description of the professional functions of technicians. On the basis of the analysis the polytechnic should identify the particular fields of engineering speciality in which training may be organised as a part of the structure of diploma courses.

We must, however, bear in mind that even when specialised training is conducted on these lines, it must be supported by a broad engineering base to equip the technician, not merely for the immediate demands of industry, but for the technological advances of tomorrow. Unless the technician is capable of adapting himself to the constant changes of technology, he will grow obsolete and superfluous. The purpose of education is essentially long-range, that is, to equip an individual to meet the challenges of his entire professional life.

5

Reorganisation of Polytechnic Courses

THESE considerations demand that we redefine the aims and objects of our polytechnics and restructure the diploma courses according to the manpower needs of our growing economy. The main objective of our polytechnics must be to train various types of technicians needed by industry, through appropriate educational processes, cross-fertilised with practical experience. To realise this objective, the structure of polytechnic courses must offer designedly different streams of training, each aimed at a cluster of technician functions in a particular engineering field. The technician functions must be identified on a continuing basis and in consultation with industry, and grouped together. Each group must cover a particular engineering curricular area.

BROAD SPECTRUM OF TECHNICIAN FUNCTIONS

Technician functions constitute a broad spectrum; no single polytechnic course can cover the whole spectrum in any major engineering subject-field. To repeat: at one end of the spectrum are near-professional functions which demand of the technician a sound, broad-based knowledge of the chosen engineering field and the ability to apply that knowledge to the day-to-day practical problems of design, construction or production in an organisation. At the other end are technicians who are required to have a mastery of manual or manipulative skills of the craftsman type, with the relevant knowledge of engineering to control and supervise production operations on the shop floor. The scope, content and standard of the educational processes for these extreme categories of technicians are totally different. In between are technicians who are required to have different proportions of professional engineering knowledge and practical skills, depending upon their precise functions in industry. Their training must, therefore, aim at equipping them for those functions. In the last analysis, each technician course must have its own integrity.

Our economy is still in a developing stage. Our technology is growing partly out of our own effort. We are also using sophisticated 'know-how' and capital equipment imported from developed countries, to speed up our industrial progress. When we have telescoped our advance in both ways in the next decade, the gap will be narrowed and we will depend increasingly upon our own native technology. In restructuring our technical education, therefore, we must keep in view the challenges that our engineers and technicians will face in the near future and the need to equip them adequately to meet those challenges. We must look upon reorganisation of technical education as a continuous process. At each stage, the system must meet the current demands of industry and must also provide for a distant technological situation that we can only dimly visualise today. Many developed countries in the history of their industrial progress have had to pay a heavy price for allowing technological advance to overrun the capabilities of their technical manpower. We must learn from their experiences and impart sufficient vitality, flexibility and capacity to effect fundamental changes to our technical education system.

RESTRUCTURING THE POLYTECHNIC SYSTEM

There are three main lines along which our polytechnic diploma courses must be restructured. These are:

(a) *To conduct a general course in civil, mechanical and electrical engineering with adequate practical content*

The near-professional functions of a technician demand that for his optimum development, he should be served by a broad based educational programme which equips him with an understanding of the basic principles of engineering and their practical application to design, construction or production processes. It must also expose him to actual working methods, techniques and skills in his field of speciality to enable him to acquire sufficient occupational competence for his professional functions.

The pattern of employment of technicians in a large number of organisations in our country to-day demands only "generalists" in the broad fields of civil, mechanical and electrical engineering. After sufficient experience, these technicians must be able to function effectively in different specialised areas in a broad field of engineering.

According to the analysis of the curriculum in Tables III and IV the structure of our present diploma courses in civil, mechanical and electrical engineering generally fulfils these requirements. These courses must, therefore, continue as the main activity of our polytechnics. It is in respect of their practical content that we need to improve immediately. We must design a purposeful programme of apprenticeship and integrate it with the structure of the diploma courses. This is best achieved by restructuring the courses of sandwich courses in close collaboration with industry, and introducing them progressively into as many polytechnics as possible. Sandwich courses in mechanical and electrical engineering have already been instituted on an experimental basis in about ten polytechnics in different parts of the country. The stage has now come when the scheme must be extended on a broad front wherever collaboration is possible between polytechnics and industry.

Two aspects of sandwich courses are important. The first is the total duration of the courses. Since practical training in industry has to be integrated, the present duration of three years of the diploma courses is inadequate and needs to be extended. The extension needed depends upon the precise programme of apprenticeship and how it is sandwiched between layers of institutional studies. Different kinds of sandwich courses are being conducted in the UK and other countries. Some are of the "thick sandwich" type and others of the "thin sandwich" type depending upon the size of the alternate layers of industrial apprenticeship and institutional studies. Further, the scope of apprenticeship depends upon the type of facilities available in the industrial establishment concerned, and how those facilities are utilised in the total educational and professional development of a technician. An institution must also coordinate and control the standards of the sandwich courses. This determines the duration and scope of industrial apprenticeship. There are therefore no universal criteria to guide our polytechnics and we must develop sandwich courses according to our own needs.

In the present state of our industry's development, a 12-month apprenticeship may conveniently be organised and integrated into the structure of diploma courses. This will extend the diploma courses to four years, but a reduction of up to six months is possible if the courses are organised on semester-basis and the long summer vacations in the latter half of the courses are utilised to cover part of the required apprenticeship programme. Whatever be the final organisational arrangements between a polytechnic and its cooperating industry, the duration of the sandwich courses should be not more than four years.

The second aspect is the nature of industrial apprenticeship *vis-a-vis* technician training in a sandwich course. The main objective of practical training is not to train a technician for a specific job in a particular industrial organisation, but to expose him to actual working methods and techniques in drafting, design and development of products, installing and operating equipment, in construction, in estimating costs and so on. The technician-trainee must be given every opportunity to observe and understand how engineering principles and their applications are translated into practical operations in the design office, on the shop floor and in the field. In this process, he should be able to acquire sufficient occupational competence to perform the same professional functions independently when employed on the job.

Apprenticeship training in a sandwich course must have a well-defined educational objective, not merely job-orientation of the future technician; and it must complement the other part of the process which takes place within the technical institution. In formulating the programme of training and integrating it into the structure of sandwich courses, therefore, there must be a close matching up of both components, each complementing the other. To realise these objectives, the programme must be evolved jointly by the faculty of the technical institution and experts in the cooperating industrial organisation. Both must share the same objectives and assume joint responsibility.

Sandwich courses must be introduced progressively into those polytechnics that are located close to industry and can establish collaboration with it. A number of polytechnics are located in semi-urban areas far away from any worthwhile industrial activity. In these polytechnics, there is no alternative but to continue the present three-year diploma courses, particularly since these areas, too, must be served by technical education facilities. For such students, however, a suitable programme of practical training must be organised in selected industrial concerns after their institutional studies are over.

(b) *To introduce technician-specialities in the diploma courses*

Depending upon the precise needs of industry for specialist technicians, we must introduce engineering specialities in the structure of polytechnic diploma courses. The engineering specialities must, however, be identified with care and deliberation and in consultation with industry. We must also ensure that a technician trained in a particular speciality has a broad engineering base, and does not become too narrow and functional, lest he be exposed to the uncertainties of employment whenever industry undergoes a basic technological change.

Two main criteria must guide the choice of specialities. First: the speciality must have an adequate content of engineering knowledge to be fit for curricular offering at a polytechnic. Second: industry must be sufficiently interested in it and agree to provide training facilities for conducting the course on a sandwich basis. As a general principle, the technician specialities must be conducted only on a sandwich system in cooperation with industry.

An activity analysis of major job titles or positions in different industrial sectors or engineering enterprises must be made on a continuing basis to identify the main specialities in which technicians are needed. The activity analysis must establish in depth and scope the precise nature of technical professional knowledge needed for different job titles, and the supporting mathematical and scientific foundation. It must also correlate the job titles with different levels of managerial, supervisory and group leadership responsibilities. In establishing these factors, we must study the actual situation in each area of technology by first-hand observation, by examining job descriptions by industry and by obtaining information and experience reports from experts concerning the scope and depth of activities involved. It is mainly through this inductive process that we can identify the areas of technician specialities and develop a purposeful engineering curriculum.

We, in India, have already progressed on these lines in organising machinery to collect the data required for manpower planning. Detailed information has been collected by the Directorate General of Employment and Training (DGET) about the number of persons employed and their occupational classifications in all public sector and private sector concerns employing 25 persons or more. The total number of persons involved in this process is at present about 14 millions. DGET has also compiled the occupational data, not just by broad categories, but in detail under 3600 occupational denominations according to a five-digit structure with brief descriptions of each category. This classification is based on a job analysis conducted by trained occupational analysis in important establishments throughout the country. DGET is extending the work to units employing 10 - 25 persons, and finally to units employing 5 - 10 persons throughout India. When these studies are complete, we will be in a position to account for the total labour force of 25 million employed persons, their occupational classifications and levels of training. This will give us a comprehensive and logical basis for manpower planning for economimc development.

The DGET occupational classification for the Group—Architects, Engineers and Surveyors, is given at Appendix I. This Group includes all workers above the level of craftsmen, who perform professional functions, including design and supervision of construction of civil engineering works; design and supervision of production, installation, operation and maintenance of mechanical, electrical and chemical engineering plant machines and tools; development of techniques for extraction and treatment of metals; planning and supervision of mining operations; conducting land and water surveys; and development of technological processes for the manufacture and treatment of various processes for the manufacture and treatment of various products. By implication and also by the nature of the duties of technicians, this Group includes technicians employed in industry with various job titles, designations and other descriptions. The DGET national classification of occupations also includes the Group—Draughtsmen and Science and Engineering Technicians, which is also given at Appendix I. This is, however, a small category since it is restricted to engineering draughtsmen and laboratory technicians and does not include the large body of technicians engaged in production construction and other engineering activities. DGET confirms that the polytechnic diploma-holders are included in the first Group.

The DGET classification of occupations in these Groups gives some insight into the different specialised engineering fields in which technicians engage and the extent to which these fields can be elaborated into specific curricular areas in the structure of polytechnic diploma courses.

The Institute of Applied Manpower Research has, through other studies, identified technician specialities in which industry needs trained personnel and suggested that our polytechnic curriculum should be restructured on a selective basis to include those specialities.

From these two sources of useful information available, a representative group of technician specialities in each major field of engineering may be suggested as below, with a broad outline of the cluster of professional activity which should be covered by curricular offerings:-

TECHNICIAN SPECIALITY	PROFESSIONAL ACTIVITY TO BE COVERED IN THE CURRICULUM
1. CIVIL ENGINEERING	
(a) Building Construction Engineering	Surveying and levelling; Design drafting; Quantities and Specifications; Materials of Construction; Estimating and Costing; Construction Methods; Maintenance of Works.
(b) Road, Highways, and Bridges	Surveying and Levelling; Design Drafting; Materials of Construction; Estimating and Costing; Construction

	Methods; Construction Supervision; Maintenance of Works.
(c) Irrigational Engineering And Hydraulic Structure	Surveying and Levelling; Design drafting of irrigational works; dams and other hydraulic structures; specifications; construction methods; supervision of construction; estimating and costing; maintenance of works.
(d) Public Health Engineering	Surveying and levelling; Design drafting of water supply, drainage and sewage disposal works; specifications; construction materials; construction methods; supervision of construction; estimating and costing, maintenance of works.
2. MECHANICAL ENGINEERING	
(a) Automotive Engineering	Machine design-drafting; assembling and fitting I.C. and petrol engines; testing and rating engines; repairing and maintaining engines; shop-floor technique and processes of producing automatic parts; estimating and costing.
(b) Production Engineering	Machine design-drafting; machine tools and metal cutting operations; Works study, method study and measurement; tool-setting; testing and standardisation; estimating and costing.
(c) Foundry and Forge Technology	Machine design-drafting; Casting and moulding materials; specifications; installation, operation and maintenance of foundry and forging equipment; estimating and costing; testing and standardisation; furnaces and fuel economy.
(d) Refrigeration & Air Conditioning	Machine design-drafting; assembling and fitting air conditioning and re-

	frigeration plant and equipment; testing and standardisation; specifications for air conditioning and refrigeration units; estimating and costing.
(e) Power Plant Engineering	Machine design-drafting; installation, operation and maintenance of thermal and hydraulic power plants; testing and rating of plants; shop floor techniques; processes of producing power plant parts; repair and assembly of power plants; estimating and costing.
3. ELECTRICAL ENGINEERING	
(a) Electrical Machines	Electrical Machine design-drafting; installation, operation and maintenance of electrical plant and equipment; testing and standardisation; shop floor techniques; processes for the manufacture of electrical machines assembling and repair of electrical machines; estimating and costing.
(b) Power Generation And Transmission	Electrical design-drafting; installation, operation and maintenance of power house; transmission system and stability; testing and standardisation; estimating and costing.
(c) Electrical Communication Engineering	Electronic design-drafting; electronic circuitry; installation, operation and maintenance of electronic communication, equipment assembling and repair of electronic equipment devices; electronic instrumentation and controls; testing and standardisation; estimating and costing.
4. METALLURGICAL ENGINEERING	
(a) Process Metallurgy	Metallurgical design-drafting; installation, operation and maintenance of

blast furnaces and steel melting plants; metallurgical process control; testing; estimating and costing.

(b) Heat Treatment : Metallurgical design-drafting installation, operation and maintenance of heat treatment plants; process control; testing; estimating and costing.

(c) Foundry And Forge Technology : Same as given for this speciality under Mechanical Engineering.

(d) Fuel And Furnace Technology : Design-drafting for furnaces and auxiliary equipment; installation, operation and maintenance of furnaces for metallurgical operations; fuels — properties, economy and testing; furnace insulation; estimating and costing.

The curricular area of each speciality as outlined above represents a logical extension of the basic engineering knowledge and skills to the functions of a technician for that speciality. It must therefore stem from the broad curriculum of the courses in civil, mechanical, electrical and metallurgical engineering.

We must visualise training in these technician specialities only within the structure of three and half or four-year sandwich courses in the major fields of engineering. The training must start in the third year of the courses after a sufficiently broad engineering foundation has been laid. The speciality must be developed in the final year for intensive instruction and practical experience in industry. We must ensure that the technician, and not merely the job, grows.

(c) *To train technicians with manipulative skills*

Our polytechnics must designedly produce technicians well equipped with a wide range of manipulative skills who are required to supervise manufacturing, construction and other engineering activities. The absence of appropriate courses to meet this demand is a major lacuna in the structure of polytechnic diploma courses. We must bridge this serious gap between polytechnics and the development of a craftsman as a technician.

No polytechnic can train a craftsman. His basic training must be conducted in separate institutions equipped for the purpose and the subsequent development of his manipulative skills must take place in industry through a well-organised programme of apprenticeship. It is the business of a polytechnic to develop the craftsman further as a technician and equip him with the needed engineering knowledge to support his practical skills.

Fortunately for our polytechnics, we have organised and developed in India a first-class system of craftsman-training at the Industrial Training Institutes (ITI) set up by the Ministry of Labour and Employment. The Institutes conduct basic craftsman training courses in about 30 different engineering trades. The duration of the training is from one to two years, depending upon the trade chosen by a candidate. The minimum educational requirement for admission to the training is general education upto Class VIII for some trades and for others like electrician, radio mechanic, draughtsman, it is matriculation. The training at the ITIs is followed by in-plant training under the Apprenticeship Act to give the candidates practical experience in their chosen fields under actual industrial conditions. The period of apprenticeship is two years for those who have had their basic training for one year at an ITI and one year for those who have had two-year basic training.

This system in which basic training in skills at an Industrial Training Institute is designedly complemented by well-organised apprenticeship in industry is producing a new generation of craftsmen who are better equipped than those who came up the hard way as journeymen. It is to this generation of craftsmen that we must increasingly look for skill-oriented technicians for the future. For their development as technicians we must design an engineering educational stream and integrate it into the structure of polytechnic courses.

The engineering curriculum for these technicians must be streamlined and self-contained. It must support the practice of skills in actual production and construction processes with an understanding of the basic engineering principles. The technician must acquire sufficient intellectual confidence to deal with different situations on the shop floor and in the field, choose the correct tools and techniques, according to job requirements, instruct skilled workers and to supervise their performance on the assigned tasks.

The main curricular offerings must cover these engineering fields in which skill-oriented technicians are needed by industry. They will necessarily project the same basic engineering disciplines as are required for other technician functions, but with a distinctive orientation towards shop floor or field level operations in production, construction, installation and maintenance of plant and equipment. The main engineering specialities in which appropriate curricula need to be designed and integrated into the structure of polytechnic education are as given on page 51.

Though the curricular offerings in these specialities will in practice cover the same areas of engineering knowledge as those needed by other categories of technicians, it is difficult academically to amalgamate them with other courses in a polytechnic. First, the curricula should aim at providing an engineering foundation for the application of practical skills and must aim at reforming and elaborating the skills already acquired by the candidates. Second, the initial preparation of these candidates, particularly in science and mathematics may not be comparable to that of high school leavers who join other diploma courses. Third, we must give adequate credit to the training received by these candidates in the ITIs followed by apprenticeship in industry. It is, therefore, desirable to design separate curricula and to offer them within the overall structure of polytechnic diploma courses at selected institutions.

To facilitate this reform in polytechnic education, a careful selection must be made of the ITI graduates while they are serving their apprenticeship in industry for admission to the technician courses. The selected candidates must be given block release during their apprenticeship and brought to polytechnics for a preparatory course in science and mathematics, and languages. Alternatively, they must be given part-day release for at least three days a week for the preparatory course. In either arrangement, the preparatory course must provide for about 500-600 hours of instruction to equip the candidates adequately for further studies.

We must visualise a two-year full-time course in these specialities within the overall structure of polytechnics and provide for the award of technician diplomas at the end of the course.

This bridge between the training of craftsmen and their subsequent development as technicians will be strengthened further when industry and polytechnics implement on a cooperative basis a scheme of block-release for serving craftsmen to undergo the technician courses. In fact, if such a scheme is launched on a national scale, it will represent the most purposeful reform of our polytechnic system. Under the scheme, industry and polytechnics must identify on a continuing basis the best among serving craftsmen capable of having training as Supervisors and sponsor them for the technician courses. These candidates must be given block-release from their normal work to attend polytechnics. The entire course must be graded into convenient blocks of institutional studies and each block must be completed at a stretch. For this purpose, the release from industry for each block must be continuous and sufficiently long. Industry must go further; it must actively support such courses as an integral part of its primary activity, and meet the expenditure on the training. This indeed is a responsibility that industry owes to itself to survive in business and improve its productivity. According to the surveys carried out by various agencies, over 7000 persons are appointed each year to supervisory positions in industry and more than half of them come up from the ranks of craftsmen and skilled workers. Their further training is a major challenge to our technical education system. This is at the core of the problem of improving industrial efficiency and profitability.

An important aspect of the curriculum of these technician courses is that they must emphasise training in Foremanship and Supervision. It is these persons who in addition to applying practical skills on the shop floor and in the field, will be responsible for the result of the group without necessarily taking part in the work. For the particular role that they play this technician is regarded as the "Sargeant-Major of Industry", "the man in the first rung of the management ladder", and so on. To equip him adequately for this role, the technician must be trained in the general principles and techniques of works and personnel management, industrial psychology, principles of production planning and control and in industrial safety. Training in all these aspects must be integrated with the total process of technician development in the works and in the polytechnic curriculum.

Engineering Specialities	*Areas to be covered by curricular offerings*	*Supporting Practical skills*
CIVIL ENGINEERING		
(a) Structural Engineering steel and concrete	Surveying and levelling; drafting; materials of construction; structural designs; specifications; quantities and estimating; construction methods; foremanship and supervision.	Building construction; welding; structural fittings; surveying; draughtsmanship.
(b) Public Health Engineering	Surveying and levelling; drafting; Water supply; drainage and sewage disposal works; materials of construction; construction methods; specifications; quantities and estimating; foremanship and supervision.	Building construction; plumbing; surveying; draughtsmanship.
MECHANICAL ENGINEERING		
(a) Automobile Engineering	Drafting; principles of automative engines; testing and rating of engines; estimating and costing; foremanship and supervision.	Fitting; mechanic (motor vehicle)
(b) Production Engineering	Drafting; machine tool technology; metal cutting processes; tooling; dies, jigs and fixtures; work study, method study and measurement; foremanship and supervision.	Fitting; turning; milling; grinding; planning; millwright tool and die making.
(c) Foundry and Forge Technology	Drafting; casting and moulding materials; installation and operation of foundry and forge plants; specifications; estimating and costing;	Pattern making; moulding.

	testing and standardisation; furnaces and fuel economy; foremanship and supervision.	
(d) Welding Technology	Drafting; welding plants; specification; strength of materials; estimating and costing; testing; foremanship and supervision.	Fitting; welding: gas and electric.
(e) Refrigeration and Air-conditioning	Drafting; assembly and fitting of plants and equipment; testing and standardisation; specifications; estimating and costing; foremanship and supervision.	Fitting; refrigeration and air-conditioning mechanics trade; electrician.
ELECTRICAL ENGINEERING AND ELECTRONICS		
(a) General Electrical Engineering	Drafting; electrical circuits; installation and testing of electrical plant and equipment; transmission and distribution; electrical instruments testing and standardisation; estimating and costing; foremanship and supervision.	Electrician trade skills.
(b) Electronics	Drafting; electronic circuitry; installation operation and maintenance of electronic communication equipment; assembly and repair of electronic equipment; devices; electronic instrumentation and controls; standardisation and testing; estimating and costing; foremanship and supervision.	Electronics or wireless trade skills.

FLEXIBLE STRUCTURE NEEDED

Though three distinct streams of diploma courses are visualised within the structure of polytechnic education, there are many points at which the courses meet one another. For instance, for both the generalist type of diploma courses and diversified diploma courses with technician-specialities there is a common broad base which covers the same areas of technical education, theory and practical. The former only extends the training of the generalist type of technician in civil, mechanical and electrical engineering throughout the course. In the latter, training in a particular technician-speciality is elaborated in depth but upon the same broad base of engineering. Similarly, the specialities for both the near-professional technicians and skill-oriented technicians cover the same areas but with difference in emphasis only.

In the employment field too, the spectrum of technician functions has more zones than sharp lines. Each zone represents a cluster of professional activities demanding varying degrees of engineering knowledge and skills according to the nature of design, production and construction work in the organisation concerned. The different zones also merge at various points as clusters of the professional duties and responsibilities of technicians telescope with advancing technology.

We must not, therefore, look upon the training of a technician as a pre-determined inflexible structure to fit closely a particular individual technician function today. Rather, the structure must be continually responsive to technological changes which, in turn, influence the nature and scope of technician functions over a wide range. It is the business of polytechnic education to anticipate the constantly changing nature of technician functions and prepare the prospective technician to rise to the challenges in his professional career. Only when his education is deeply rooted in the broad principles of science and engineering and the process extended to actual practical experience in the field is the technician equipped for his optimum development. These guiding principles must inform all polytechnics in their effort to restructure their diploma courses.

ORGANISATIONAL CHANGES NEEDED

Reorganisation of polytechnic education on those line demands two fundamental changes. First, institutions which are prepared to restructure their courses must be given full academic freedom to do so. They must be free to develop the curriculum along the best lines possible in consultation with industry, emulate higher standards and establish a coherent relationship between education and industry. Second, industry must be made to accept apprenticeship as its legitimate responsibility both for its own survival and for the progress of our society.

As explained before, polytechnic education was in an almost chaotic state in the early 1950s. The courses varied widely in duration and standards from institution to institution. Different authorities administered the institutions in different States at their discretion. There were no well defined national objectives for the polytechnic courses. To establish some order, the All-India Council for Technical Education and its Boards of Technical Studies worked hard to evolve a national system of polytechnic education with clearly enunciated objectives, uniform standards and an unified administration for the institutions in each State. In this process, a Board or Council of Technical Education was set up in each State to which all the institutions in the State were affiliated. The affiliation visualised that the State Board or Council would prescribe the details of the courses including syllabus and standards, hold examinations and award diploma. Though in these 15 years polytechnic education has been systematised throughout India, the present organisational and administrative structure has imposed much rigidity on the institutions. It has deprived well-established and forward-looking institutions of freedom to experiment with the much-needed reforms, collaborate with industry in organising and conducting sandwich courses, introduce technician specialities and to redesign the curriculum of diploma courses to meet the current and future needs. All institutions have been compelled to follow a rigid pattern of courses, curriculum, standards and examinations as prescribed by an outside authority which precludes the effective participation of the faculty of polytechnics and experts from industry. This has led to a sort a steam-rollering of all institutions to conform to a rigid pattern. However, the All-India Council never visualised such a rigid approach by State authorities in charge of polytechnic education. The situation 15-20 years back was so chaotic that some order was necessary to evolve a national structure for polytechnic courses which could guarantee minimum standards. It was not really the intention of the All-India Council that the State Boards or Councils should deprive good institutions of freedom to experiment, to innovate and to demonstrate new approaches to the training of technicians.

ACADEMIC FREEDOM FOR INSTITUTIONS

This position notwithstanding, the stage has now come when carefully selected polytechnics should be given complete academic freedom by their respective State Boards or Councils to restructure their diploma courses on the lines suggested earlier, establish cooperative relationships with industry in their regions, develop new curricula for the courses and evolve their own methodology for technician development. They should also be permitted to conduct their own examinations for the new courses and after assessing the standard of the examinations held, the State Boards/Councils should award diplomas. As and when other polytechnics are in a position to undertake similar reforms for their technician diploma courses, they too, should be given the same academic autonomy. Finally, the State Boards or Councils must divest themselves of the function of conducting examinations and become standard-setting and standard-assessing bodies. They should help, guide and oversee the progressive development of their institutions along correct lines, instead of being merely controlling authorities.

The academic autonomy given should, however, be exercised by the institutions not as administrative fiats of the principals of the institutions, but through collective participation of the faculty and experts from industry. For this purpose, an advisory committee should be set up for each polytechnic, which should consist of senior faculty members, experts from industry and other academic experts to advise the institution on a regular basis on all academic and organisational aspects of technician courses and to watch over their standards.

In addition to academic freedom, those polytechnics which are in a position to restructure their courses must be invested with adequate administrative powers. About 70 per cent of our polytechnics are State Government institutions administered by the State Directorates of Technical Education. As Government institutions, their administration and management are rigidly controlled by these departments and a formidable amount of redtapism and bureaucracy confronts the heads of all institutions. The Principals are hardly able to implement any reforms regarding faculty development, equipping of laboratories and workshops, selection of students for admission or any other aspect of administration of their institutions without the approval of their Directors. The remaining 30 per cent of our polytechnics, administered by private agencies through managing committees, are proving no better since the managing committees have merely supplanted the State Governments and their administrative departments.

In the interest of progress and further development of polytechnics, a drastic change is urgently needed. The Principals must be delegated adequate administrative and financial powers to manage their institutions and implement new programmes, for restructuring diploma courses without hindrance. These powers are particularly needed for the development of the faculty (through in-service training, apprenticeship in industry, advanced training, etc.,) equipping laboratories and workshops according to the needs of the courses, holding seminars, conferences and discussion in association with industry, engaging the services of experts from industry on part-time basis, setting up curriculum development groups and for preparing and publishing instructional materials.

RESPONSIBILITY OF STATE AND CENTRAL GOVERNMENTS

Reorganisation of polytechnic education on these lines also demands adequate financial provision for the institutions. Unfortunately, all institutions function at a bare subsistence level. The budget of government institutions is strictly controlled by the State Governments whose only anxiety seems to be to cut expenditure at the expense of quality of education. Non-government institutions are worse off since they can meet only a part of their expenditure from the income from tuition fees and depend heavily upon grants from the State Governments. The grants-in-aid codes of State Governments are so restrictive that any expenditure on quality improvement is ruthlessly cut as inadmissible and the institutions are left crippled. The Central Government has borne 50 per cent or more of the expenditure on the establishment and maintenance of the institutions for the first five years. It is also bearing the entire expenditure on the training of teachers and on other programmes like summer institutes. It is, therefore, inconceivable that State Governments whose primary responsibility is to maintain and administer polytechnics along the best lines should seek to disown this responsibility on grounds of economy or lack of resources.

A fundamental change of attitude among the State Governments is urgently needed. They must accept the main responsibility for the improvement and development of polytechnic education as theirs and concern themselves seriously with the problem in this field. The Central Government, too, has an important role—to take a total and integrated view of the whole system on the national plane, identify the immediate and long range objectives of polytechnic education, *vis-a-vis,* industrial development, lay down rational standards of education and training, and provide expert advice for the improvement of polytechnics on a continuing basis. The Centre must also back up the efforts of the States with what resources it can allocate in critical areas, as for instance, teacher-training, curriculum development, apprenticeship in industry, innovations and experimental projects and so on. Unless the roles of the States and the Centre are well coordinated and harmonised and both share responsibility, polytechnic education cannot move forward.

AMENDMENTS TO APPRENTICE ACT

The cooperation of industry is the most important aspect of the problem of reforming polytechnic education. Since the restructuring of polytechnic education is crucial to our industrial productivity a down-to-earth policy must be formulated and implemented. To this end, the Apprentice Act 1961 must be amended to require industry to assume responsibility for the practical training of students of degree and diploma courses in their works. The number of training places that each factory must provide, the programme of training and other important details must be determined by Apprenticeship Advisors appointed for the purpose. Further, the Act must provide for a compulsory levy on industry for financing apprenticeship schemes, generally on the same lines as the British Apprenticeship Act which has made a big impact on the British technical education scene. The levy may be on the basis of either the gross value of the products of manufacture or services of the firm or the total wage bill of its employees. The proceeds of the levy must be pooled and made available for the apprenticeship schemes under the control of a Central Apprenticeship Council. Wherever a firm conducts its own apprenticeship programme according to the principles and standards laid down by the Apprenticeship Council and also bears the full expenditure on the programme, it must be given a suitable rebate on the levy, or alternatively, the expenditure must be reimbursed from the Central pool.

Fortunately, there is increasing awareness among industrial establishments in the private sector of their responsibility for practical training and many establishments are offering training places each year to students of technical institutions. Several public sector enterprises too have followed suit though the attitude of others is anything but enlightened. The main defect of the existing facilities is that at many establishments there is no well-designed programme of training to complement the theoretical studies at technical institutions with actual industrial experience of design, production and construction. The training is also not supervised adequately; the students are left to fend for themselves. These defects must be corrected through the Apprentice Act and industrial establishments required to implement correctly designed programmes of training and assume full responsibility for supervising the training with qualified persons.

The amendments formulated by the Government of India to Apprentice Act 1961 go far towards these objectives, except that they do not visualise any levy on industry. Industry will be required only to provide apprenticeship with supervision and bear the entire expenditure. It will also be required to bear 50 per cent of the expenditure on stipends to the trainees. Though these proposals are not unsatisfactory, a definite levy on industry is necessary. First, a separate fund can be created to finance all types of apprenticeship to complement academic educational programmes. Second, wherever a firm fails to provide adequate apprenticeship, equivalent facilities can be organised elsewhere. Third, every industrial unit will be involved in financing apprenticeship programmes according to its size and in fulfilment of its obligations to society. Finally, industry is committed to improving productivity; productivity demands better engineers and technicians and their training therefore is a first charge on industry.

ACCREDITATION OF POLYTECHNICS

Another fundamental organisational change needed is in respect of coordination and maintenance of standards. At present, the All-Indian Council for Technical Education and its Boards of Technical Studies lay down the broad structure of polytechnic diploma courses, syllabi and other details to indicate the minimum standards to be maintained by institutions on an all-India basis. These are adopted or adapted by State Boards of Technical Education and prescribed for the institutions affiliated to them. This arrangement worked satisfactorily so far, and brought about some order into the otherwise chaotic situation which prevailed prior to 1950. Now that academic freedom must be given to selected institutions to restructure their courses and to experiment with and innovate new forms of technician education in consultation with industry, it is important for the Central Government to keep a careful watch over the further development of polytechnic education and ensure that adequate standards are maintained by the institutions. The Central Government must also evaluate the performance of the institutions on a continuing basis and feed back the information to State Boards and other agencies which are in immediate charge of technical education. For these purposes, an independent agency to act as a watch dog over academic and professional standards is necessary. The All-India Council for Technical Education should set up a National Accreditation Board and vest the Board with authority to recognise institutions. Only those institutions which are accredited to the Board must be deemed to be conforming to minimum national standards of technical education.

6

Curriculum Development

WE HAVE redefined the objectives and goals of our polytechnic system and explained the lines along which the diploma courses must be restructured to reach those objectives and goals. We have given a broad analysis of the spectrum of technician functions, *vis-a-vis,* design, construction, production, testing and maintenance of plant and equipment in industry. We have gone further: on the basis of the activity analysis of technician positions, we have indicated the types of knowledge, skills and judgment needed by a technician both for his immediate employment and for his future professional development.

CONTENT OF DIPLOMA COURSES

Upon this groundwork, our polytechnics must determine what precisely a technical student should learn in three or possibly four years of formal study to prepare him for employment as a technician. How much science and mathematics should he study—and of what kind? Since this is a programme of *education* as well as *training,* how much "general education" should there be and what subjects should be included? Can there be a common "core" of science, mathematics and technical courses to serve as the basis of preparation for a number of related technician specialities? How to develop an integrated sequence of instruction in different subjects?

These are only a few of the problems of curriculum-making for polytechnic courses.

The general structure and content of the present diploma courses as an institutional preparation for the near-professional type of technicians are not found wanting in the essentials. If backed with adequate apprenticeship in industry, the courses will be even more useful. The main reasons for the polytechnics not making the desired impact on technician education is that an adequate curriculum has not been developed as an essential guide to teachers to improve the teaching and learning processes. All that the polytechnics have is a syllabus which outlines the subject areas and topics to be covered in the courses. The teachers are not generally aware of the precise goals of instruction in each subject, the depth to which the subjects need to be taught, how to co-ordinate theory with practice, how to develop fundamental concepts and understanding in the students and make them apply to practical problems in engineering. The absence of suitable text-books and other materials specially produced for the diploma courses of our polytechnics is another serious handicap. Often, polytechnic teachers use books which are followed by engineering colleges for the degree courses and depend upon the examination question papers of previous years as a guide to the standards expected of polytechnics. In a word, we have gone about this work in a hit-and-miss way.

Major institutional changes are urgently needed to improve the teaching and learning processes in our polytechnics. In fact, upon those changes will be success of the restructuring of diploma courses suggested earlier depend. An organised effort must be made on a national level to hammer out a model curriculum in all the subject-fields of diploma courses and also in the different technician specialities. For this purpose, groups of specialists must be set up at selected centres and they must work full time for the next four-five years intensively till a first rate curriculum is developed. The curriculum must be tried out and tested with the help of teachers, refined in the light of actual classroom experiences and offered to polytechnics with adequate flexibility for adaptation to suit their local conditions.

Another important task of these expert groups would be to develop appropriate laboratory experience design specific experiments for both classroom demonstrations by teachers and to be performed by students and produce prototypes of experimental apparatus and instruments.

Apiece with curriculum development is the preparation of instructional materials like teaching units for different subjects, teachers' guides and laboratory, manuals. These, too, must be included in the programme of work of the expert groups. Later, competent teachers must be selected and given the task of writing textbooks based upon the curriculum and instructional materials developed by the expert groups.

The present examination system for our polytechnics is obsolete and follows conventional methods of testing the textbook knowledge of students, not their understanding of the basic principles of engineering and their application to practical problems. Much of the home tasks and sessional work make no demands upon creativity. These are the areas in which reforms are urgently needed. Objective type of examinations must be introduced to test and evaluate the effectiveness of the courses on the one hand, and, on the other to assess the performance of the students. For this purpose, the faculty of polytechnics, paper-setters and examiners of State Boards must be trained with the help of specialists in educational evaluation and measurement.

A big national programme must be mounted for curriculum development, preparation of instructional materials including textbooks, development of laboratory experience and for examination reform. In this programme, the faculty of polytechnics, experts from industry and pegagogists must be closely involved. Seminars, workshops and conferences must be organised for the exchange of ideas and experiences and interaction between educationists and industrial experts.

To develop the curriculum, the specialist groups in consultation with experts in industry must identify the main categories of technician positions in design, production, construction, testing and other areas of engineering activity, delineate the exact professional duties and responsibilities of technicians, determine the type and extent of engineering knowledge and practical skills needed. From this analysis, they must derive the content and standard of individual subjects to be taught in a sequential pattern to constitute the curriculum of polytechnic courses. An activity analysis of technician positions in each engineering field is the basis of curriculum development. As an illustration of the type of effort needed, an activity analysis of technician functions in machine tool industry is given at Appendix II. This has been prepared by Messrs Hindustan Machine Tools Ltd., Bangalore.

PLACE OF MATHEMATICS AND GENERAL SCIENCE

Mathematics must be given an important place in the polytechnic curriculum since it is the language of engineering and all technicians must have adequate ability to comprehend and communicate in that language. The type and extent of mathematics needed in the polytechnic curriculum must be determined *vis-a-vis* the standard and content of technology theory that a technician must have in his course. The aim should be to give the technician an understanding of the mathematical principles and procedure underlying engineering and not to equip him with problem-solving skills. The teaching of mathematics should not be in abstract; it should develop round the type of engineering problems that a technician has to understand analytically. This demands, in adition to the basic concepts of algebra, trigonometry, mensuration, graphics and calculus, the application of the concepts to an understanding of a physical situation in engineering and its interpretation in mathematical terms.

In the present polytechnic diploma courses mathematics is taught to all students generally in the first year and the total number of contact hours (lectures and tutorials) is only about 120 or 3.5 per cent of the total curricular time. This is grossly inadequate, particularly since the standard and content of school mathematics of most entrants to polytechnics leaves much to be desired. In addition to making up this deficiency, the polytechnic curriculum has to bring up the mathematical preparation of the students to a level where the teaching of technology becomes meaningful. This is a crucial task of the curriculum development groups.

Next to mathematics, general science—physics, and chemistry is important in the all-round education of a technician, but the teaching of these subjects should not be looked upon as a mere extension of school science. The primary objective should be to give the students an understanding of the physical and chemical principles underlying engineering, like conservation of mass and energy, electricity and magnetism, combustion, etc. Live examples from engineering must be chosen to explain the fundamental scientific concepts and their application, instead of straight narration of properties of matter or chemical reactions or similar parts of pure physical sciences. As far as possible, science teaching should be integrated with engineering so that the students can get a real feel for engineering through the application of physical and chemical principles.

WORKSHOP TRAINING IN POLYTECHNICS

The nature and scope of workshop training must be clearly defined since there is still some confusion about the place of workshop in the polytechnic curriculum. The main objective is to acquaint the students in practice (depending upon their field of study) with the production of materials, their moulding and processing, as well as with the finished products in composition, structure and mode of action. In addition, it familiarises them with the testing of a finished workpiece and with the assembly of machines and apparatus, installation and control. In civil engineering the training has to deal with actual construction methods and techniques, stability and strength of structures and various other aspects relevant to that field. This is also true of other engineering fields in which appropriate to each of them the training has to deal broadly with the processes and techniques, operations and controls, the functioning and capacity of machines, all geared to the attainment of a pre-determined objective. To achieve this objective, workshop training must fulfil three tasks. First, to acquaint the students with the production or construction methods. The training for which only limited time is available (contrary to conditions in the training of specialist skilled workers), has to be systematic so that the trainee may become acquainted with a whole range of methods and thus gain wider experience. The trainee should also try to understand the principles underlying the various methods of production and extend this knowledge in that field. The training of specialist skilled workers and the practical training of students of engineering are quite different things. The purpose in training the former is to impart to them the manual skill that is required in their occupation and that is acquired by repeatedly practising on the same workpiece. The training of an engineering student, on the other hand, is intended to show him how the same final shape of a workpiece can be produced, by means of different methods in accordance with constructional requirements. The workers' training is intensive, the students' practical training is more extensive, although the latter cannot dispense with a certain degree of manual skill. The knowledge and experience which he gains during his practical training are essential later on to his professional work.

Next, the prospective engineer or technician must become acquainted with works organisation which governs the structure and functioning of a factory. Third, the trainee should get to know the Works Community; the sociological problems of that community; the worker as an individual, his strivings, his urges and his psychology; and the relationships between labour and management.

Only when an engineering student has completed a definite programme of practical training on these lines, can he be regarded as possessing the minimum experience required for entry to the profession.

In Britain, Europe, USA and other industrially advanced countries, these requirements of practical training are met in full through well organised programmes of apprenticeship in industry. Industry in those countries has also set up training centres attached to the works for the preliminary training of students before they are sent to the actual floor for work under production conditions. In India, few of our industrial concerns conduct such apprenticeship programmes. Even those concerns which offer practical training facilities to technical students expect them to come after preliminary training elsewhere. In these circumstances, workshop training at polytechnics occupy an important place in the curriculum of diploma courses. Training in the workshop of a polytechnic can never supplant apprenticeship in industry. As an integral part of the polytechnic curriculum, it complements technology (theory) on the one hand, and, on the other, prepares the students effectively for apprenticeship in industry later. Since in the absence of any type of pre-vocationl preparation at the school stage in our country, most entrants to polytechnics do not have even a rudimentary knowledge of tools and materials, the workshops of polytechnics must fill an important gap for them. It is here that they are exposed for the first time in their lives to working with their hands and helped to develop engineering skills.

An important task of the curriculum groups is to suggest how best to organise and conduct workshop training at polytechnics, to prepare graded exercises in metal cutting, fitting, carpentry, foundry and forge, welding and other operations to equip the students with a knowledge of tools, materials and processes; to prepare manuals for the guidance of instructors; and to extend the programme of training in advanced shop practice to mechanical and electrical engineering students according to their course requirements. The main approach should be to make workshop training meaningful and significant within the polytechnic curriculum.

A frequent complaint of our industry is that polytechnic diploma-holders cannot readily adapt themselves to industrial atmosphere and lack understanding of the personality of an industrial enterprise and its functions. In defence of the diploma-holders, it may be argued that adaptability to industrial work develops when they are put through the paces in a well organised programme of apprenticeship supervised by industry. It is, however, necessary that education at polytechnics should mould the attitudes of students towards the discipline of work in life and dignity of labour. A large number of our students come from those strata of society where the traditional caste and social distinctions have not disappeared. Even after their education at a university or technical institution, those students do not show any evidence of a radical change in their attitudes and values. Apparently, the type of education given has only stuffed them with book knowledge leaving their minds and critical faculty untouched. This is precisely what needs to be corrected if our polytechnic diploma-holders have to be prepared and equipped for a professional way of life in industry. The polytechnics curriculum must build into the students the correct attitude and values which characterise an industrial society. The attitude-formation must be integral to the teaching of science, technology and social sciences. It must be emphasised further when the students go to industry for apprenticeship.

DEVELOPMENT OF ENTREPRENEURIAL SKILLS

The main objective of our polytechnics at present is to prepare candidates for jobs in large and medium industries. The content and methodology of the curriculum and every other aspect of the polytechnic system are directed to this objective; to identify the types of jobs available in industry, the professional technical competences needed to perform adequately in those jobs and develop the appropriate courses content and teaching units. While our polytechnics must achieve this objective, they should also address themselves to an equally important aspect, namely, to develop in the students entrepreneurial skills to help them set up small and medium industrial units of their own after graduation. In fact, self-employment for the products of our technical institutions will in future years hold the key to some of the social and economic problems of India. The number of young persons who have had the benefit of education beyond the school stage is increasing steeply and has outstripped the employment opportunities generated by the present rate of economic development of our country. The problem of the educated unemployed has already assumed menacing proportions. Even our engineering graduates and polytechnic diploma-holders in recent years are seriously affected by various economic forces which have inhibited industrial development. If the polytechnic system has to be an important form of vocational education to equip young persons for gainful occupation in life, it is axiomatic that it must develop entrepreneurial attitude and skills and self-reliance in the student constituency that it seeks to serve. If the polytechnics succeed in doing so by addressing their curriculum to this objective, the diploma-holders will not only have created a rewarding professional life but also have participated effectively in the industrial development of our country.

In rural areas, the present farm revolution has brought in its wake a big demand for engineering units to service tractors, pumps and pump-sets and other types of agricultural machinery, and also to produce their components. Setting up of cold storage plants for the storage of farm products and other units to give a technological basis for agricultural development is urgently needed. In urban and other areas, the increasing demand for engineering goods and services can only be met by expanding the small and medium industry sector. This sector also has vast potentiality for producing engineering components and parts required by heavy and large manufacturing plants. Our polytechnics must designedly orient the content and methodology of the diploma courses to equip their candidates for entrepreneurship and to exploit these vast opportunities in the rural and urban sectors of our growing economy.

This, however, is not to suggest that a separate polytechnic curriculum needs to be developed. In the normal curriculum, various subjects can be taught so that students learn to apply engineering principles and skills to the design, manufacture and fabrication of various products. They can also be given the minimum knowledge needed of market survey, estimating and costing, setting and industrial organisation. It is a question of well planned and imaginative approach, rather than one of a different curricular offering. The same curriculum must, in addition to supplying a broad spectrum of technician functions in industry, also supply the know-how of entrepreneurship.

POLYTECHNIC SYSTEM VIS-A-VIS EDUCATIONAL STRUCTURE

How does the proposed re-organisation of the polytechnic system fit into the future educational structure in our country?

The Education Commission (1966) has recommended the following educational structure:

—A pre-school stage of one to three years
—A primary stage of seven or eight years
—A lower secondary or high school stage of three or two years in general education or of one to three years in vocational education
—A higher secondary stage of two years of general education or one to three years of vocational education
—A higher education stage of three or more years for the first degree followed by the second or research degree of varying duration.

At the end of the first ten years of school education there should be an external examination to qualify a student for the higher secondary stage or for vocational education of various types or for working life. The Commission has also visualised that vocational education should not be a part of the normal school system, but that separate provision should be made for it at two stages, one at the end of Class VII/VIII and another at the end of Class X for those students who "step off" the main educational stream to enter working life. The ten-year school system should be structured mainly for general education in languages, social studies, science and mathematics. The following two-year higher secondary stage should be college/university preparatory.

There are wide differences between State and State in the school system and large financial outlays are needed to make the system uniform throughout our country as visualised by the Commission. Further, to expand the school system to 12 years demands major structural changes along with adequately trained teachers and instructional facilities in high schools. Reorganisation of our educational system according to the recommendations of the Education Commission will therefore extend over many years. Till then, the present ten-year high school or eleven-year higher secondary school system will continue. As a sequel, the present polytechnic diploma courses with matriculation or higher secondary as the minimum admission qualification must continue.

Even after the educational system has been restructured throughout our country, it is the ten-year high school which will supply students with adequate general education in languages, science and mathematics for our polytechnics. It is also at the end of this stage of school education that the Commission has visualised the main diversion of students to various types of vocational education including polytechnics. The higher secondary stage will extend school education by two years mainly to prepare students for college or university education. Though we would wish that students with twelve-year high secondary education were available for polytechnic courses, particularly in those subject-fields like electronics which demand better preparation in science and mathematics, we cannot set any store by it at this stage. The interests of these students in higher education will have been fixed and only those who cannot make the grade for colleges will drift to polytechnics. That will hardly serve the cause of polytechnics.

From both the immediate and long range points of view, no fundamental changes are needed to fit the polytechnic system into the general educational structure in our country. It will, however, be an overwhelming drawback in our polytechnic system that most students embark upon these professional courses without any vocational preparation at the school stage. The only remedy is to devise measures for the necessary preparation outside the school system for those students who wish to enter polytechnics later.

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The Polytechnic Student

IF THE structure of diploma courses, curriculum, organisational aspects, technician specialities and skills are all important aspects to the polytechnic system, equally important, if not more so, is the polytechnic student himself. In the final analysis it is he who has to benefit from the system created at great cost and effort. It is therefore important for us to know all about the polytechnic student body which exceeds one hundred thousand at present. Who are these students and to which socio-economic strata of our society do they belong? What is their educational background and how are they motivated to polytechnic education? What kind of guidance and counselling service is available to them and how do these students fare in the polytechnic courses? These and other aspects must be constantly studied to gain new insights into our polytechnic system if we wish to make the system an instrument of social and economic change.

SOCIO-ECONOMIC BACKGROUND OF POLYTECHNIC STUDENTS

According to the survey carried out by the Education

Commission in 1966 the socio-economic background of the polytechnic student body is as given below:

I.	Number of institutions covered by the study: 172	
	Percentage of students from:	
	Rural Areas	44.4
	Urban Areas	55.6
II.	Occupation of Parents:	Percentage
	Professional	7.7
	Service	32.0
	Business	19.1
	Agriculture	28.6
	Others	12.6
III.	Income of Parents:	
	Less than Rs. 150/- p.m.	55.8
	Between Rs. 151-300/- p.m.	25.4
	Between Rs. 300-500/- p.m.	11.8
	Over Rs. 500/- p.m.	7.0

Though over 44 per cent of the students belong to rural areas, a majority of the polytechnic student body (72 per cent) belong to the non-agricultural strata of our society. This is the group which completes high school education with a view to going up to a University. It, however, drifts to polytechnics partly because it cannot make the grade for admission to an engineering college and partly because of economic circumstances. Few students have any specific occupational interest in industry before joining polytechnics. They also receive little guidance or counselling at the school stage to help them choose the right career according to their abilities.

EDUCATIONAL LEVEL AND PERFORMANCE OF STUDENTS

Another comprehensive survey has been made of the calibre of the students admitted to polytechnics in 1968/1969 in each State and their performance in the diploma courses. The results are summarised in Tables V and VI. The first table gives the proportion of the students admitted with different grades of achievement in the school final examination—60% marks and and above, between 50% and 60% marks, between 45% and

50% marks and below 45% marks. The proportion varies widely from State to State. The variations are more pronounced in the larger States which account for a majority of our polytechnics.

TABLE V

STUDENTS

S. No.	State/Union Territory	Number admitted (in percentage) with different marks in the qualifying examination			
		60% marks or more	Between 50 and 60% marks	Between 45 and 50% marks	Less than 45% marks
1	2	3	4	5	6
1.	Maharashtra	18	42	25	15
2.	Gujarat	5	38	34	23
3.	Madhya Pradesh	22	33	23	22
4.	Pondichery	9	39	26	26
5.	Goa	20	40	26	14
6.	Madras	16	44	25	15
7.	Andhra Pradesh	27	45	23	5
8.	Mysore	5	14	21	60
9.	Kerala	7	35	31	27
10.	Uttar Pradesh	11	39	41	9
11.	Rajasthan	13	39	43	5
12.	Haryana	6	27	25	42
13.	Chandigarh	5	46	49	—
14.	Punjab	7	41	34	18
15.	Himachal Pradesh	9	41	45	5
16.	Assam	2	9	13	76
17.	Bihar	Information Incomplete			
18.	Tripura	nil	nil	100	—
19.	Jammu & Kashmir	7	45	28	20
20.	Manipur	2	9	9	80
21.	Orissa	3	18	19	60
22.	West Bengal	6	25	26	43

TABLE VI

EXAMINATIONS

S. No.	State/Union Territory	Performance of students in percentage in the first year examination			Percentage of students completing the diploma course successfully in three years	Percentage of students taking more than three years
		Pass in all subjects	Placed in Compartment	Fail		
1	2	3	4	5	6	7
1.	Maharashtra	36	22	42	20	80 (4 years)
2.	Gujarat	40	20	40	20	80 (4 or 5 years)
3.	Madhya Pradesh	38	23	39	31	60 -do-
4.	Pondicherry	22	16	62	25	75 (4 years)
5.	Goa	38	22	40	10	90 (4-5 years)
6.	Madras	32	30	38	60	40 (do-)
7.	Andhra Pradesh	30	17	53	51	49 (5 yrs & more)
8.	Mysore	22	34	44	47	53 (4-5 years)
9.	Kerala	50	15	36	61	39 (4 years)
10.	Uttar Pradesh	50	18	32	56	44 (4-5 years)

11. Rajasthan	55	22	23	47	53 (-do-)
12. Haryana	44	29	27	53	47 (-do-)
13. Chandigarh	65	31	4	80	20 (-do-)
14. Punjab	64	27	9	60	40 (4-5 years)
15. Himachal Pradesh	—	—	—	92	8 (4-5 years)
16. Assam	43	—	57	30	70 (5 years)
17. Bihar	State Board does not hold public examination at the end of first year			57	43 (4-6 years)
18. Tripura	-do-			28	72
19. Jammu & Kashmir	60	30	10	90	10 (4-5 years)
20. Manipur	Information not furnished			10	90 (4 years)
21. Orissa	68	15	17	70	30 (4 years)
22. West Bengal	State Council does not hold public examination at the end of first year			53	47

The national average is as shown below:

Students admitted:	
with 60 per cent marks and above	10 per cent
with marks between 50 and 60 per cent	32 ,,
with marks between 45 and 50 per cent	31 ,,
with marks below 45 per cent	27 ,,

If we regard 50 per cent marks as the minimum scholastic level needed for technical studies, 58 per cent of the students entering polytechnics are below that minimum level and poor achievers at the school stage. Those who enter with a relatively better scholastic achievement constitute only 10 per cent of the student body, an almost insignificant proportion.

This position is again reflected in the performance of the students in their studies at the polytechnics as in the next table where the results of the examinations held by the State Board of Technical Education at the end of the first year of the Diploma Courses are analysed. The analysis indicates the proportion of the students who clear all the subjects in the first attempt, those who fail in all the subjects and those students who fail in some subjects but are allowed to continue their studies in the next higher class as compartmental students. Here again the position varies from State to State. The overall position is as shown below:

Percentage of:	
Students who pass in all subjects	44
Students who fail in all subjects	34
Students who fail in certain subjects and are placed in compartment	22

According to this survey over a third of the students admitted to polytechnics fail to make the grade in all the subjects of the first year of the diploma courses. About a quarter of the students fail in some subjects and only about 44 per cent complete the course successfully. The survey results also show that only about 47 per cent of the students complete the diploma courses successfully within the prescribed period of three years; the rest take four or five years to do so.

The faculty of the polytechnics too are not satisfied with the quality of entrants to diploma courses. According to them, the students come inadequately equipped with science, mathematics and communication skills at the school stage and the five years is extremely hard going for most of them. Since they have had no pre-vocational preparation they find themselves in a strange world when they enter a polytechnic and have to face serious problems of adjustment. Lack of motivation and aptitude for technical studies also adds to their difficulty, particularly since none of these factors is taken into consideration while selecting students for admission to polytechnics. The present method is purely mechanical; students are selected from among the applicants according to the marks secured by them in the school final examination.

PRE-VOCATIONAL PREPARATION OF STUDENTS

The present position demands a totally different approach to the problem of polytechnic student body. If polytechnics have to have a well defined place in our educational system we must designedly create a hinterland from which it can recruit its students who are suited to the type of technical education that we can offer. If on the other hand polytechnics continue to be the dumping ground for those school leavers who cannot make the grade for colleges they will fail to produce the correct type of technicians needed by industry. All our efforts to restructure polytechnic education and improve is quality and standard will fail.

It is unfortunate that our school education is purely "academic", straightjacketed and has no vocational goals. It is equally unfortunate that the "multipurpose school" programme accepted on the recommendation of the Secondary Education Commission (1952) was given up halfway after much infructuous expenditure and effort. If only the "multipurpose school" system had been allowed to develop it would have provided a suitable recruiting ground for polytechnics. The Junior Technical Schools were killed by doubting academic Thomases before they had a chance to function and demonstrate their usefulness. In these circumstances the only source from which our polytechnics can recruit students is the conventional secondary schools and that will continue to be so till secondary education is reformed with specific vocational bias. But, we must innovate immediately within the present school system to motivate and equip selected students for polytechnic education.

The only practicable innovation is to reach out to high school students with additional facilities of instruction in workshop, drawing, science and mathematics outside the normal school system to prepare and motivate them for polytechnic education. How to do that?

We have at present about 350 Industrial Training Institutes and 270 Polytechnics located throughout the country. They all have excellent workshop facilities and instructors. A secondary school student gets at least six months of long vacation—two months at a stretch in each of the eighth, ninth and tenth class-years (or ninth, tenth and eleventh class-years in the higher secondary school system). If we can only bring selected students who are interested in joining polytechnics to these Industrial Training Institutes and polytechnics during vacations and give them a well graded programme of workshop practice and instruction in drawing, science and mathematics to back up their school curriculum this pre-vocational preparation of about six months will condition them for polytechnic education and minimise the present problems of polytechnic student body. Future entrants to polytechnics must be selected only from among those students who have had this initial preparation. We have all the resources to launch on a programme of this type and what we need is the will to do it. There need, however, be no commitment on the part of these students to join polytechnics and even if some of them do not join at the end of their school education the training given will enrich them.

An alternative is to organise and conduct this programme for six months at a stretch after the students have completed school studies and restrict admissions to polytechnics to those who have undergone the training. The only constraint to this alternative is that the students have to wait for nearly a whole year to get admission to polytechnics and many students might not agree to wait that long without any incentives. Since, however the present position of the polytechnic student body is far from satisfactory and no fundamental changes in school education can be visualised in the near future our polytechnics in their own interest must adopt selective process to demand of students seeking admission to be equipped suitably for technical studies. As long as adequate facilities for such initial preparation are designedly made available no section of the student population can have legitimate cause for complaint.

Both alternatives explained earlier, in-vacation and after-school training can be offered and students allowed to choose one or the other according to their individual circumstances. If this programme is organised and developed along correct lines, we will have laid a good vocational base for school leavers, not merely for polytechnic education but for other types of vocational education. Since the students who will take advantage of these training facilities belong primarily to the low-income groups, the State must provide free lodging and board at the training centres. This expenditure will be much less than what would have cost the State for vocationally-oriented education within the school system.

SCHOLARSHIP FOR POLYTECHNIC STUDENTS

In addition to less than average achievement at the school final examination, a large proportion of the entrants to polytechnics belong to the economically weaker sections of our society. Though not fully established, these two factors are not unrelated. Since, however, polytechnic education for the State is an investment in human resources development the question of care and maintenance of these students is important. According to the reports received from polytechnics most students find it extremely difficult to meet the expenditure on their education which ranges from 100 to 125 rupees a month, and includes tuition fees, books and instruments and lodging and board in a hostel. This is a serious situation which demands the urgent attention of both the Central Government and State Governments.

In 1960, the Central Government introduced a scheme of Merit-cum-Means Scholarships to help students of merit but with inadequate means in their studies in engineering colleges and polytechnics. These scholarships which were of the value of 75 rupees for an engineering college student and 50 rupees for a polytechnic student with full exemption from tuition fees were allotted to each engineering college and polytechnic proportionately to the number of students admitted each year. Under the scheme, each technical institution including polytechnics had a definite quota of scholarships to offer to its students according to their merit-cum-means. The criteria of eligibility were that the students should have secured the first division or at least 60 per cent marks in the qualifying examination—matriculation or higher secondary or pre-university as the case may be, and that the annual income of his parents or guardian should not be over 6000 rupees. When the scheme was in full operation about four per cent of the polytechnic student body was covered by scholarships. By correlating the scholarship—coverage with the proportion of those students who entered polytechnics with the first division or at least 60 per cent marks in their qualifying examination it is evident that the scheme helped exclusively a small top section of the polytechnic student body and was not designed specifically towards improving the general level of polytechnics by attracting an increasing proportion of average and above average achievers at the school final examination. Those students who were eligible for the scholarship according to the prescribed merit-cum-means criteria were not attracted to polytechnics because of the scholarships offered, but for other reasons. The scholarships were awarded only after the students had been admitted.

The Merit-cum-Means Scholarships Scheme for technical students was later integrated with the National Scholarships Scheme, and the practice of allotting a specific number of scholarships to each technical institution was done away with. Under the National Scholarships Scheme, the Central Government allots to each State a specific number of scholarships to be awarded on the basis of merit-cum-means, to those students who qualify at the matric/higher secondary examination to help the most meritorious but poor students in their further studies. Once a student is awarded a scholarship under this scheme, he is free to pursue any course of studies, in the sciences, humanities, engineering and so on. Over 6000 scholarships are awarded each year to fresh students qualifying at the examinations. The new arrangement has not affected the number of scholarship-holders entering engineering colleges. In fact, the number of students has increased because of the higher social status attached to the degree and the economic returns of engineering education at the college level. The position of polytechnics, however, has become worse. Hardly any of the scholarship-holders is entering polytechnics, and even the few scholarships that used to be allotted to these institutions under the old Merit-cum-Means Scholarships Scheme have been taken away.

It is evident that if polytechnic education is regarded as an integral part of higher education, it will suffer from disabilities in competition with other types of institutions. If we wish to improve polytechnics, we must attract designedly an increasing proportion of average and above average high school leavers who have a distinct interest in and aptitude for vocational education. For this purpose, a special scheme of scholarships is needed with different merit and means criteria from those of the National Scholarships Scheme. These scholarships should cover at least 50 per cent of the polytechnic student body and awarded primarily to those who have undergone pre-vocational training at the school stage, preparatory to polytechnics. Further, polytechnic education should be made free for all students.

In the final analysis, the importance of polytechnic education from the students' point of view will increase only when industry accords due status to technicians and offers them rewarding opportunities, both financially and professionally. Industry can be expected to play its part if it is assured of well trained diploma-holders of acceptable standard. The restructuring of the polytechnic system discussed earlier will bring the system into a close relationship with industry, but it needs the necessary inputs, particularly students and teachers. It is, therefore, the business of the State to make an all-out effort to help polytechnics overcome their present disabilities.

FURTHER EDUCATION OF DIPLOMA-HOLDERS

Another factor responsible for good students not being attracted to polytechnics is that the diploma courses are a dead end road and few opportunities are available at present for diploma-holders to study further and advance in their profession. It is true that diploma courses cannot be regarded as a preparation for degree courses, but if polytechnic education has to be an important part of our overall technical education system we must build bridges across engineering colleges and polytechnics to facilitate the further studies of meritorious students. To meet this demand, on the recommendation of the All-India Council for Technical Education the Central Government sanctioned in 1962 a scheme of part-time degree courses at selected engineering colleges to provide facilities of further study for diploma-holders serving in industry. Initially, 30 centres were approved and it was visualised that on the basis of the experience gained facilities for part-time courses will be extended and ultimately, a network of such facilities spread throughout our country. It was also visualised that a fair balance must be reached between full-time and part-time courses. Unfortunately, because of lack of interest of engineering colleges in part-time courses and the rigid academic attitude of universities to such courses the scheme has not made much progress. All but five centres have discontinued the courses and the present enrolment of part-time students is less than 500 as against about 100,000 in full-time courses.

The only avenue open to diploma-holders to advance in the engineering profession is to sit for the examinations for the Associate Membership of the Institution of Engineers and other professional bodies. A pass in those examinations is recognised as equivalent to a degree for professional appointment in industry and government organisations. Since, however, there are no organised coaching facilities for those examinations the diploma-holders are finding it increasingly difficult to study privately and prepare themselves adequately in all the subjects. The rate of failure is very high and many students give up the effort.

We must correct the situation immediately by organising adequate instructional facilities for the examinations of professional bodies at as many selected polytechnics as possible. The members of the professional bodies who are all qualified engineers can do much to help the polytechnics in this worthwhile programme by serving as part-time teachers and guiding the polytechnic faculty. Further, the professional bodies must extend adequate credit for the diploma courses by exempting the candidates from some of the papers of their Associate Membership examinations. The polytechnic centres must secure the services of the college faculty in their neighbourhood as part-time teachers.

To locate these training courses at polytechnics is to improve the status and importance of these institutions. The faculty of the polytechnics will also feel that they can participate in higher academic work which today is the exclusive concern of engineering colleges. The earlier scheme of part-time degree courses, though well intentioned, suffered in actual practice on account of two factors. First, the faculty of engineering colleges looked down upon it as an inferior type of academic work as compared to the full-time courses and accepted it unwillingly as an unnecessary appendage to their institutions. Second, universities in our country did not respond favourably to the idea of part-time studies for their degrees. These are precisely the reasons why in a vast country like ours, part-time and correspondence courses have made little progress even in such fields as the humanities and social sciences. Though the present student enrolment at the university stage exceeds two millions, less than two per cent are in part-time and correspondence courses. It is unfortunate that few universities feel concerned over this situation, notwithstanding their claim that their existence has a great social relevance. To learn while one earns seems to be a totally alien idea to our universities and other institutions of higher learning.

8

The Polytechnic Faculty

THE HEART of every educational institution is the teacher. It is the quality of staff that, in the final analysis, guarantees the success of an educational system. This is even more so far a technical institution where the nature of studies makes close contact between teacher and taught imperative and demands of the former both academic excellence and professional competence.

PATTERN OF POLYTECHNIC FACULTY

The present strength of our polytechnic faculty is about 10,000 teachers, most of whom have been recruited in the last 10-15 years when polytechnic education was expanded. The staffing pattern as laid down by the All-India Council for Technical Education for a polytechnic conducting diploma courses in civil, mechanical and electrical engineering (with 120 admissions each year or a total student body of 360-400) is as given below:

Principal	1
Heads of Deptts.	3 — One each for civil,

	mechanical and electrical engineering
Lecturers in Engineering	5 — 2 for civil, 2 for mechanical and 1 for electrical
Workshop + Superintendent	1
Head Draftsmen	2
Instructors	2 — For mathematics, science and general education subjects.
Demonstrators	7 — For science and engineering subjects
Assistant Instructors	7 — For workshop practice
Draftsmen	3

This staffing pattern which has been generally adopted by all polytechnics gives an overall teacher-student ratio of 1:12. For polytechnics with larger student enrolments, the All-India Council has recommended additional staff at the level of lecturers and instructors.

Though the teacher-student ratio of 1:12 is satisfactory the present staffing pattern suffers from several serious inadequacies. First, for each subject-field, civil, engineering, mechanical engineering or electrical engineering, provision has been made for only one senior teacher above the level of lecturers, who is also the head of department. Since the head of the department has many organisational and administrative duties to perform in the institution, and is also not an expert in all the specialities of his subject-field, the bulk of the teaching work has to be done by junior teachers at the level of lecturers and instructors who are not all well trained and equipped for the purpose. Second, the teaching of science and mathematics is left entirely to the care of just two instructors without a head of department or lecturers to guide them. The rather poor standard of science and mathematics at our polytechnics is largely because of inadequate teaching. Third, the ratio of senior to junior posts is 1:7, a very unfavourable ratio for the career advancement of the staff on the one hand and on the other, for a balanced sharing of teaching and organisational responsibility within a polytechnic.

These and other inadequacies in the staffing pattern of polytechnics must be corrected. As a first step, we must strengthen the present faculty:

—by providing at least two senior positions (to be designated as Senior Lecturers) at the level of heads of department for each of the civil, mechanical and electrical engineering fields;
—by providing a position at the level of Head of Department for science and mathematics and strengthening this faculty further by converting the present posts of Instructors into Lecturers to attract better qualified persons for polytechnic teaching;
—by suggesting to all polytechnics that when the faculty is strengthened on these lines, the actual teaching should be done by teachers at the level of Lecturers and above and Instructors and Demonstrators should only assist them in laboratory and other practical work.

These are the minimum improvements needed in all polytechnics, but at those institutions where the diploma courses are diversified in cooperation with industry for the training of specialist technicians additional positions should be created at the level of Senior Lecturers according to the technician-specialities introduced. We must realise that unless the polytechnic faculty is adequately strengthened and equipped none of our present proposals for the restructuring of diploma courses will succeed.

Till recently there was an acute shortage of staff (over 40 per cent) in all polytechnics even according to the pattern recommended by the All-India Council for Technical Education. The shortage was partly because of the big expansion of polytechnic education during the Second and Third Plan periods and partly because of unattractive pay scales and other terms offered for these teaching positions. To improve the position various measures were adopted, the most important of which was to upgrade the pay scales. The Central Government agreed to revise the pay scales as below as also to bear the additional expenditure for a certain period:

Principal	Rs. 800-50-1250
Heads of Deptts.	Rs. 600-40-1000-50/2-1150
Lecturers (including	Rs. 350-350-380-30-590-30-

Workshop Superintendents)	770-40-850
Instructors & Demonstrators and equivalent staff	Rs. 260-10-300-15-450-25/2-500

These revised scales were generally adopted by all State Governments and the Central Government provided assistance for well over ten years. As a result of this measure and the action taken by institutions to expedite their recruitment procedure the position improved considerably. According to a survey carried out in 1968-69, the overall shortage of staff in polytechnics was only 20-25 per cent. Experience has shown, however, that even these revised pay scales compare unfavourably with those in industry and cannot attract well qualified and experienced persons from industry to teaching.

PRACTICAL EXPERIENCE FOR POLYTECHNIC FACULTY

The quality of our polytechnic faculty still remains to be much improved at all levels. The All India Council has recommended the qualifications and experience for the polytechnic staff as below:

Designation	*Qualifications*
Principal	Degree in Engineering at least in the second division, with not less than 8 years' professional experience of which 4 years should be in teaching.
Head of Department Civil Mechanical Electrical	Degree in the appropriate branch of Engineering at least in the second division with not less than five years' professional experience of which at least two years should be in teaching.
Lecturers	Degree in the appropriate branch of engineering at least in the second division with not less than two years' professional experience.

Head Draftsmen	National Certificate or equivalent in the appropriate branch of engineering with at least 5 years' drawing office experience.
Workshop Superintendent	Degree in mechanical engineering at least in the second division with five years' workshop experience.
Instructors (Mathematics, Science and General subjects)	Degree in the appropriate subject at least in the second division with not less than two years' teaching experience.
Demonstrators	National Certificate or equivalent qualification in the appropriate branch of engineering with at least one year experience.

Though the staff recruited fulfil the prescribed academic qualifications, a large proportion lacks adequate industrial experience. According to a survey conducted in 1969 (Table VII, pages 90-91) over 55 per cent of the teachers in position have had no industrial experience; about 24 per cent have had industrial experience of at least two years but less than five years; and only 20 per cent have had industrial experience of five years or more. This is one of the main reasons why our polytechnic education is not sufficiently practical. Much of the teaching is theoretical, not backed up by actual practical experience in the field or factory. If we have to improve the polytechnic system we must first improve and develop the faculty of our institutions.

The immediate need is to bring our polytechnic teachers to industry during vacations and at other times and equip them with adequate practical experience in their subject fields. An organised programme of practical training must be developed and implemented in cooperation with industry. The programme must be addressed to the curricular requirements of the polytechnic courses and in particular to the functions of a technician in industry, in construction, production, design-drafting, installation and operation of plant and equipment and testing. The training must help the teacher in teaching his subject from a practical standpoint and with a surer understanding of the nature of technician functions. The practical training programme for serving teachers must be regarded as a continuing process of faculty development in which all teachers are exposed to industry at regular intervals, and bring to bear upon their teaching work, knowledge and experience of the changing industrial techniques and practices. A sympathetic understanding of the problems of our polytechnics must be created in industrial organisations to accelerate the process of faculty development. Industry must be made to realise that it is in its own interest to help in the training of the better technicians that it needs and extend its cooperation to polytechnics in implementing the programme.

POLYTECHNIC FACULTY DEVELOPMENT

A large proportion of the polytechnic faculty has entered the teaching profession without any methodologic and didactic preparation. Since the polytechnic student-body consists largely of those who are average and below average achievers at the school stage and the general age of entry to the institutions is 15-16, few teachers, irrespective of their academic qualifications can be effective unless they are specially prepared for this type of work. Further, since most of the senior teachers have come straight from engineering colleges with or without industrial experience they are unacquainted with the problems of teaching at the polytechnic level. It is not uncommon to witness teaching out of books or lecture notes at dictation speed and the students reproducing those notes at examinations. Few teachers use effectively charts, graphs, films, film strips and other audio-visual aids.

To remove these serious deficiencies and train better teachers for polytechnics, the Central Government decided to set up four Regional Institutes at Madras, Chandigarh, Calcutta and Bhopal. All the Institutes have started functioning with courses specially designed for the training of teachers on a full-time basis. Two types of courses are offered at present, one for teachers who are graduates in engineering and another for those who hold a diploma. The former which extends over 18 months includes 12-month practical training in selected industrial organisations. This is followed by training in pedagogical methods and practice teaching in a polytechnic. The course for diploma-holders extends over two and half years and includes the same periods of practical

TABLE VII

TEACHERS

S. No.	State/Union Territory	Overall teacher student ratio	Proportion of teachers (in % having)		
			Five years or more industrial/practical experience	At least 2 years but less than five years industrial/practical experience	No industrial/practical experience
1	2	3	4	5	6
1.	Maharashtra	1:10	23	31 (less than 2 years experience-22)	46
2.	Gujarat	1:13	13	24	63
3.	Madhya Pradesh	1:8	9	26	65
4.	Pondicherry	1:6	nil	8	92
5.	Goa	1:7	12	17	71
6.	Madras	1:12	Information not furnished		
7.	Andhra Pradesh	1:12	5	21 (23 possess 1 year experience)	74
8.	Mysore	1:8	25	18	57

9.	Kerala	1:11	30	25	45
10.	Uttar Pradesh	1:16	19	20	61
11.	Rajasthan	1:8	7	8	85
12.	Haryana	1:5	21	22	57
13.	Chandigarh	1:15	13	16	71
14.	Punjab	1:11	25	20	55
15.	Himachal Pradesh	1:7	10	90	—
16.	Assam	1:7	8	7	85
17.	Bihar (information for only three institutions received)	1:14	9	44	47
18.	Tripura	1:5	50	44	6
19.	Jammu & Kashmir	1:5	6	19	75
20.	Manipur	1:10	91	9	—
21.	Orissa	1:8	18	26	56
22.	West Bengal	1:7	21	21	58

training in industry and training in pedagogical methods as for graduates. For the remaining 12 months, the candidates are given intensive training in the basic sciences followed by training in the technical skills and content of their fields of speciality.

These courses of the Teacher Training Institutes have been very useful in training the correct type of teachers for polytechnics. Since, however, admissions to the Institutes are restricted to serving teachers sponsored by their respective institutions there is an urgent need for two specific measures to ensure the success of the Institutes. First, all those teachers who have undergone these training courses must be granted adequate advanced increments in their present positions, or alternatively, they must be promoted to the next higher posts by creating such posts wherever necessary as supernumerary. Unless these incentives are offered in recognition of the effort made by the teachers to improve themselves professionally, few teachers are attracted to the Institutes. Next, State Governments and other authorities in charge of polytechnics must sponsor as many of the serving teachers as possible for this training and bear the additional expenditure involved. Unfortunately, the attitude of most State Governments towards teacher training is far from satisfactory. The State Governments feel that once they have set up polytechnics their responsibility should cease and the progressive improvement of standards must either occur automatically or be the responsibility of some one else. As long as this attitude continues, and the State Governments feel they have no stakes in improving technical education on a continuing basis it is futile to suggest any programme of faculty development. It is to be hoped that the State Governments will view the problems of polytechnic education in the correct perspective of national development and take a positive stand on the urgent measures needed to solve the problem.

Each Teacher Training Institute is designed to train ultimately about 60 teachers each year. Even when all the four Institutes are functioning fully they will train only about 240 teachers each year. The total number of serving teachers in our polytechnics is about 10,000. At this rate it will take at least 40 years to retrain all those teachers. Nor do all the teachers require full time training for 18/30 months as offered by the Institutes at present. For quick and effective results we must think of other measures.

Faculty development is a long and continuous process in which a wide range of opportunities must be provided to serving teachers to improve their professional competence according to their own needs. Some teachers need shorter courses to update their knowledge in their special fields. Others need similar courses to acquaint themselves with the correct methodology of teaching their subjects, use of audio-visual aids or to develop laboratory experience along new lines. Yet others need opportunities to improve themselves in other directions. These varying needs must be met by designing appropriate courses and offering them on a continuing basis throughout the year. Teachers must be encouraged to attend the courses regularly whenever they can get away from their institutions and renovate themselves. A great deal of imagination is needed in designing the courses and conducting them.

The Central Government in cooperation with US AID initiated in 1962 a programme of Summer Institutes to provide serving teachers of technical institutions with an opportunity to update their knowledge in their subject-fields and exchange experiences and ideas among themselves. The programme was conducted at selected polytechnics throughout the country with the help of Indian and American experts. Following the success of the first Summer Institutes the programme has since been continued each year and about 3000 teachers of polytechnics have had the benefit of Summer Institute courses. Though it is too early to assess the impact of the programme a process of change in polytechnics is being gradually felt. At least, those teachers who have attended the Summer Institutes have started doubting the validity of whatever they have been doing all these years without question. That is the starting point for any process of change. The teachers have also started changing their attitude to the established class room and laboratory practices notwithstanding the many hurdles that are still in the way of a complete transformation. The teachers are now more aware of the relationship between polytechnic education and the needs of industry for well trained technicians.

The Summer Institutes are important means of faculty development and must continue to be held regularly, till all our polytechnic teachers have had the benefit of this training. The programme must go further; each and every teacher must have opportunities of attending Summer Institutes at least once in two or three years. Advances in science and technology are rapid and obsolescence of knowledge is a serious problem, particularly among teachers. Unless the knowledge of a teacher is continually improved his teaching becomes dead routine, neither rewarding to him nor useful to his students.

The programme of Summer Institutes must be complemented with other forms of in-service training specially addressed to the varying needs of teachers. They must be conducted throughout the year for periods ranging from two weeks to eight weeks, so that a teacher can attend them whenever he can get away from his institution for short periods. The courses must be designed with great care and deliberation and focussed on the different aspects of the polytechnic curriculum, like the sequential development of a subject-field, associated laboratory experience, and reorganisation of laboratory practical work, design and development of audio-visual aids, elaboration of technician functions and the curricular foundations needed for them. Teams of experts must be set up at selected centres to assess the needs of polytechnic teacher on a continuing basis, help in the formulation of the courses, evaluate the impact of the training and advise the centres on the further development of the programme.

Faculty development is at the heart of the problem of reorganisation of polytechnic education. This demands an organised and massive effort on a broad front.

Our polytechnic teachers are often criticised for being resistant to any change in the curriculum or teaching methods or in the examination system. This is not true. A large number of teachers, particularly those who have participated in the Summer Institutes are responsive to the need to change and in fact, are anxious to bring about an all round improvement in the polytechnic system. All that they need is encouragement and support from the State Boards of Technical Education and State Directors of Technical Education who control the destiny of polytechnics in the States. The attitudes of these authorities need to be changed if the teachers are to make any marked improvement in the polytechnic system. The feeling of the teachers that they are helpless in a rigid system which is remotely controlled by an impersonal and unchanging authority like the State Boards should be removed and direct lines of communication opened up between teachers and State Boards. As the first step, teachers' councils should be set up by the Boards to advise and guide the total process of polytechnic education and provide them with an opportunity to participate effectively in decision-making in academic matters.

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9

Engineer-Technician Ratio

WHAT IS the correct engineer to technician ratio for our country and how shall we plan for it?

PRESENT POSITION

Our technical institutions are training at present (1969) about 15,680 graduate-engineers and 22,750 diploma-technicians each year. The ratio of engineer to technician is 1 : 1.45. The admission capacity of the institutions is about 25,000 students to the degree courses and about 50,000 students to the diploma courses. The out-turn of graduates is about 80 per cent of the admissions and that of diploma-holders only 60 per cent of admission. When the full admissions are made, our institutions will produce 20,000 graduates and 30,000 diploma-holders each year. The engineer to technician ratio will be 1 : 1.5.

The number of engineering graduates in employment in 1968 was estimated to be 1,24,000 and that of diploma-holders 1,51,300. The engineer to technician ratio is thus 1 : 1.22.

COMPLEX FACTORS

The general view is that we are producing too many engineers and too few technicians with the implied under-utilisation of the former. The view is supported by the fact that according to a survey of representative government organisations conducted in 1962-63, about 40 per cent of the positions held by graduates could have been filled with diploma-holders. The All-India Council for Technical Education has recommended that the desirable engineer to technician ratio should be 1 : 3 or 4. The Education Commission has recommended an overall ratio of 1 : 2.5 by 1975 and 1 : 3 or 4 by 1986.

The issue, however, is more complex than these arithmetical calculations. As the Institute of Applied Manpower Research has rightly pointed out:

> "It would seem to be a risky proposition to accept any of these ratios as applicable to the whole of the economy or even to different sectors of industries or technology because more detailed studies indicate that the ratio of technicians to an engineer is a derived index of engineering employment in a country under existing conditions and pattern of industrial production and other forms of industrial activity, as well as several other factors including the type and quality of technician and graduate engineering education. The ratio also depends on the manner in which the technician specialities are grouped, the level of industrial development of the country, and the stage of scientific development of the subject-matter".

The Institute has compiled the data of engineer to technician ratio in the manufacturing industry in the different industrially advanced countries. These are reproduced in Table VIII. The ratio varies from 0.7 in Denmark to 4.7 in the United Kingdom. To illustrate how this variation is emphasized from one sector of industry to another, the data for the United Kingdom are reproduced in Table IX. For comparison, the distinction of mechanical and electrical engineering posts in India in 1964 by economic activity is given in Table X.

As for India, there are several factors which make it difficult for us to evolve a rational basis for determining the engineer to technician ratio. First, our industry is still in a developing stage and dependent largely upon imported know-how, capital equipment and managerial techniques. In this situation few industrial enterprises distinguish the precise role of an engineer *vis-a-vis* a technician. The main demand of industry is for technical personnel who can instal plant and equipment, apply imported know-how and produce the goods and services for which a particular enterprise is set up. In this type of activity no distinction is made between an engineer or technician and the recruitment of personnel is often governed by the salary levels and supply of graduates and diploma-holders.

Second, the future policy of our industry is not clear. Though technological self-sufficiency is repeatedly proclaimed as our national goal the efforts made to reach the goal within the stated time do not seem to reflect our earnestness. This is evident from the fact that the total R & D expenditure is about 145 crore rupees, which is only 0.43 per cent of the gross national product. The share of industry in this R & D expenditure is only eight crore rupees or about six per cent. In the industrially advanced countries, the R & D expenditure ranges from two to three per cent of the gross national product, and industry's share is over fifty per cent. Unless, therefore, our industry adopts a more progressive attitude towards and makes increasing investments in research and development technological self-sufficiency will be a mere profession not matched by performance. With that go all the opportunities of gainful employment for our graduates and the optimum utilisation of their abilities in research, design and development work. With that also continues the unequal competition between engineers and technicians for the available jobs.

Third, our industrial organisations have no well defined personnel policy to guide the recruitment of engineers and technicians according to specific job requirements. It is not uncommon to see advertisements where for the same positions either a degree or diploma in engineering is demanded, but the job description is of the technician type. The stand of industry is that as long as a recruit possesses a degree or diploma, it can lick him to shape to suit its specific requirements and decide whether the individual should perform the functions of an engineer or technician depending upon his abilities. What matters to industry is his experience and not his potentiality and educational

TABLE VIII
TECHNICIANS AND ENGINEERS IN MANUFACTURING INDUSTRY IN VARIOUS COUNTRIES

Country	Univ. Trained Eng.	Other Trained Eng.	Total Trained Eng.	Tech.	Tech./Tot. Eng.	Labour Force	Tot. Eng./ Labour Force
(1) Belgium (1959)†	48.4*	50.1*	98.5*	143.6*	1.5	1,566,000	.0098
(1) Denmark (1959)†	46.9*	37.1*	84.0*	53.5*	0.7		.0084
(1) France (1959)†	NA	NA	109.7*	176.2	1.6	6,300,000	.0110
(2) Ireland (1964)	NA	NA	378.0‡	871‡	2.3	35,601‡	.0106
(1) Sweden (1) (1960)†	42*	89*	131.0*	105*	0.8	NA	.0131
(1) Switzerland (1955)†	NA	NA	14,440.0	17,100	1.2	NA	NA
(3) U.K. (1965)	NA	NA	84,529.0	398,374	4.7	NA	NA
(4) U.S.A. (1962)	NA	NA	480,300.0	379,500	0.8	NA	NA
(5) U.S.S.R. (1959)	NA	NA	343,300.0	860,900	2.5	20,205,000	.0169

N.A.=Not Available

* Number per 10,000 in the working force.

‡ Number from sample of 120 firms only.

† The data for these countries includes the number of engineers and technicians in non-manufacturing industry.

TABLE IX

DENSITY OF EMPLOYMENT OF ENGINEERS, TECHNOLOGISTS AND SCIENTISTS TECHNICIANS AND OTHER TECHNICAL SUPPORTING STAFF IN U.K., BY INDUSTRY

Manufacturing Industry

	1962		1965						
Industry of employer	Total employees (000's)	Engineers, technologists and Scientists (1) %	Total employees (000's)	Engineers and technoligists (1) %	Scientists (1) %	Engineers, technologists and Scientists (1) %	Technicians (1) %	Technician—Engineer Ratio ÷ Col. (8) ÷ (7) %	Engineer/Scientist Ratio Col. (7) : (6) %
1	2	3	4	5	6	7	8	9	10
Food, drink and tobacco	724	0.4	714	0.2	0.4	0.6	1.8	3.0	0.5
Chemicals and allied industries	446	4.1	437	1.5	3.1	4.6	7.7	1.7	0.5
Excluding mineral oil refining	416	3.9	410	1.3	3.0	4.2	7.6	1.7	0.4
Mineral oil refining	30	6.4	27	4.8	4.5	9.2	10.1	1.1	1.0
Metal manufacture	595	1.0	602	1.0	0.2	1.2	4.5	3.8	5.0
Mechanical Engineering	1,766	1.1	1.772	1.1	0.1	1.2	6.6	5.5	10.0

Electrical Engineering and electronics	753	2.4	808	1.9	0.7	2.6	9.4	3.6	2.7
Electrical Engineering	461	—	478	1.6	0.3	1.9	7.5	4.0	5.3
Electronics	292	—	330	2.4	1.2	3.6	12.2	3.4	2.0
Vehicles etc.	953	1.2	948	1.1	0.1	1.2	7.1	5.9	10.1
of which motor vehicles	431	0.5	504	0.5	—	0.6	3.6	6.0	—
Aircraft	287	2.5	254	2.2	0.5	2.7	16.2	6.0	4.4
Textiles clothing etc.	1,432	0.3	1,295	0.2	0.2	0.4	2.1	5.2	1.0
of which cotton-flax and man-made fibres	273	0.8	233	0.5	0.5	1.1	3.8	3.5	1.0
Other manufacturers	1,463	0.4	1,493	0.3	0.2	0.5	2.4	4.8	1.5
Total:-	8,133	1.1	8,070	0.8	0.4	1.2	4.9	4.1	2.0

Note: (1) As a percentage of total employees. "As technicians" cover all the technical staff, supporting engineers, technologists and scientists, the ratio in (Col. 9) of the Table is worked out between all technicians (Col. 8) and all qualified engineers, technologists and scientists (Col. 7)

TABLE X

DISTRIBUTION OF MECHANICAL AND ELECTRICAL ENGINEERING POSTS IN 1964 BY ECONOMIC ACTIVITY

(a) ALL-INDIA

(i) ALL POSTS

Speciality Economic Activity	Mechanical and Electrical posts held by						
	Mech. Degree Holders	Elec. Degree Holders	Mech. Degree Holders	Elec. Diploma Holders	Ratio of graduates to Diploma Holders	Persons not possessing a degree or diploma in Mech./Elec. engg.	Total
1	2	3	4	5	6	7	8
I. Electrical Power Supply	762	3872	869	4133	1 : 1.08	2309	11945
II. Mining; Manufacture of Metal and Metal Products	2237	1042	1755	655	1 : 0.73	3006	8695
III. Manufacture of Machinery and Equipment	3296	1328	4508	1633	1 : 1.11	3531	14296
A. Electricals	703	980	1452	1165	1 : 1.55	980	5280
B. Motor Vehicles and Transport Equipment	877	123	1460	200	1 : 1.66	1070	3730
C. Other Machinery	1716	225	1596	268	1 : 0.96	1481	5286

IV. Manufacture of other Products	*1688*	*758*	*2568*	*1247*	*1 : 1.11*	3362	9623
A. Chemical and Products	406	205	462	213	1 : 1.1	309	1595
B. Textiles	383	235	622	435	1 : 1.71	1167	2842
C. Foodstuffs	176	60	448	216	1 : 2.81	676	1576
D. Misc. Products	723	258	1036	383	1 : 1.45	1210	3610
V. Construction	1104	456	1520	1112	1 : 1.42	1195	5383
VI. Transport and Communications	802	811	1181	1109	1 : 1.41	1452	5353
VII. Education	1622	1178	1748	966	1 : 0.97	528	6042
VIII. Govt. Administration	2390	1116	3734	1635	1 : 0.53	8918	17793
IX. Misc. Services	454	437	330	180	1 : 0.57	669	2070
All Activities	14355	10998	18213	12670	1 : 1.22	24966	81202

preparation for the functions of an engineer or technician.

Fourth, when we identify an engineer or technician according to his educational preparation, the framework fails wherever in industry no clear-cut distinction is made between the relative functions and engineers and under-utilised as technicians. The situation becomes more complex when a large number of persons possessing neither a degree nor a diploma but only practical experience are promoted to the ranks of engineers or technicians within an organisation. These persons called "Practicals" constitute a substantial proportion of engineering manpower in industry. According to a survey of "Employment of Mechanical and Electrical Engineering Manpower in India—1964" conducted by the Institute of Applied Research, there were:

Degree holders	—	33,000
Diploma holders	—	41,000
Practicals	—	32,000

These 32,000 "Practicals" were distributed among those grades or levels of employment where degree and diploma holders were employed. If all these "Practicals" are counted in as technicians the ratio of engineers to technicians is 1:2.2. This shows how wide the variations can be when the ratios are determined according to the educational qualifications of the manpower employed. Again, depending upon how these "Practicals" are classified—as engineers or technicians or partly as engineers and partly as technicians--we get different ratios of engineer to technician.

In the industrially advanced countries too a large proportion of engineering manpower consists of "Practicals" who have come up the hard way from the ranks of skilled workers, with experience. The conditions obtained in those countries, however, are different. All those countries are experiencing acute labour shortage and have to maximise the utilisation of their qualified engineers and technicians. It is only when the supply of engineering manpower falls short of the demand that workers with experience are promoted to fill vacant technical positions at higher levels. In India, there is no shortage of qualified engineers and technicians, at least not now. Still, according to conservative estimates at least 5,000 unqualified persons rise to supervisory positions each year in our industry.

BROAD GUIDELINES FOR FUTURE PLANNING

These complexities of the Indian situation notwithstanding, we must evolve broad guidelines for the future planning of our technical education system. Till the technological development of our country is consolidated and R & D activity in industry expands on the requisite scale we should peg admissions to engineering colleges at the present level to reach an engineer to technician ratio of about 1:2 in the next five or six years. Meanwhile, the standard and quality of polytechnic diploma courses should be improved to train the correct type of technicians needed by industry. The present high rate of wastage at polytechnics should be brought down through pre-vocational preparation of students, at the school stage, improved curriculum, and better teaching and learning processes. We must ensure that at least 75-80 per cent of the students admitted complete the diploma courses successfully within the prescribed period.

We cannot wish away the large numbers of "Practicals" who rise to technician positions each year. This aspect of engineering manpower will continue, but we must design and implement adequate educational programmes to equip them for technician positions. As explained earlier, part-time courses specially addressed to these "Practicals" to reinforce their practical experience with theoretical engineering knowledge should be organised on an extensive scale.

All these measures are integral to the whole business of restructuring our polytechnic system discussed in previous chapters. Their success depends not entirely on the faculty of our polytechnics. It is the response of industry to technician education and the cooperation extended by it to polytechnics which will determine the pace and direction of progress in this field in the years ahead.

The immediate responsibility of our industry is twofold. First, to carry out on a continuing basis an activity analysis of all jobs to identify technician positions according to the skills and educational preparation needed and feed the information to polytechnics to help them reorganise their courses. Next, to adopt definite manpower policy of restricting recruitment to technician positions to those who have been specially trained for the purpose and to accord to technicians their due status in the industrial enterprise.

APPENDIX I

National Classification of Occupations

GROUP 00 ARCHITECTS, ENGINEERS AND SURVEYORS

Workers in this group design and supervise construction of civil engineering works; design and supervise production, installation, operation and maintenance of mechanical, electrical and chemical engineering machines, tools and equipment; develop techniques for extraction and treatment of metals; plan and supervise mining operations; conduct land and water surveys; and develop technological processes for manufacture and treatment of various products.

000 ARCHITECTS

Workers in this family plan layout and coordinate development of urban areas and design buildings, monuments, etc.

000.10 TOWN PLANNER designs layout and coordinates development of towns, cities, and colonies, taking into consideration various aspects such as financial resources, location of industries, residential areas, schools, parks, etc.

000.20 ARCHITECT prepares designs for construction of buildings, monuments, etc., estimates cost and coordinates functional and organisational details for execution of plan. May advise Town Planner *(000.10)* in remodelling or development of towns, colonies, etc.

000 CIVIL ENGINEERS (INCLUDING OVERSEERS)

Workers in this family design and supervise construction of civil engineering works, direct or attend to repairs and maintenance of such works and specialise in any particular branch of civil engineering such as irrigation, highways, sanitation, etc.

001.10 CIVIL ENGINEER, GENERAL plans and supervise construction of buildings, monuments, airfields, rail tracks, bridges, dams, and other civil engineering works. Prepares estimates of materials and cost of construction according to specifications. Directs repairs and maintenance of buildings, monuments, airfields, etc.

001.15 CIVIL ENGINEER, IRRIGATION specialises in designing and construction of irrigation projects. Surveys sites to ascertain suitability for construction, prepares designs, estimates cost, supervises construction and directs repairs and maintenance work.

001.20 CIVIL ENGINEER, HIGHWAYS specialises in construction and maintenance of public roads. Estimates cost, supervises construction and directs maintenance.

001.25 CIVIL ENGINEER, RAILWAYS specialises in designing, laying, constructing and maintaining of railway tracks, terminal yards, bridges, tunnels, turn tables, cabins, etc. Takes safety measures in case of floods, landslides, etc.

001.30 CIVIL ENGINEER, SANITATION specialises in construction and maintenance of sanitary engineering works such as drainage system, sewers, etc. Estimates cost, supervises construction and directs maintenance.

001.50 OVERSEER, CIVIL ENGINEERING supervises construction of buildings, roads, dams, airfields, drainage systems, etc., according to specifications and attends to repair and maintenance work. Controls labour and material. May estimate cost.

001.80 CIVIL ENGINEERS, OTHER specialise in designing, constructing and maintaining of civil engineering works and include those specialising in multistoreyed buildings, light houses, etc., not elsewhere classified.

002 MECHANICAL ENGINEERS

Workers in this family design machines, tools and other equipment, supervise their production, installation, operation and maintenance and specialise in any particular branch of mechanical engineering such as automobiles, aeronautical, marine, structural air conditioning, etc.

002.00 MECHANICAL ENGINEER, GENERAL supervises production, installation, operation and maintenance of machines and equipment. May specialise in any particular branch of mechanical engineering such as internal combustion engines, steam engines, turbines, boilers, etc. May design machines and equipment.

002.10 DESIGNER, MACHINES designs machinery such as mechanical plants, lathes, conveyors, milling machines, cranes, etc., for purposes of production. May specialise in particular types of machinery such as textile, agricultural, printing, etc.

002.15 TOOL ENGINEER designs tools, jigs, fixture and other mechanical equipment for purposes of production. May specialise in designing particular types of tools such as press tools, form cutters, hammer dies, etc.

002.30 MECHANICAL ENGINEER, PRODUCTION plans production according to schedule. Devises time-saving methods and enforces their application. Ensures free flow of work for mass production of units and components. May design or alter tools and equipment for efficient production.

002.35 MECHANICAL ENGINEER, MAINTENANCE checks machines and equipment to ensure that they are in proper working order, services and overhauls machines periodically. Makes emergency arrangements in cases of breakdown. May instal machinery and equipment.

002.40 MECHANICAL ENGINEER, AUTOMOBILE specialises in designing, manufacturing and repairing of cars, trucks and other motor vehicles.

002.50 MECHANICAL ENGINEER, MARINE specialises in designing and manufacturing of engines and other mechanical equipment of ships, boats, tugs, dredgers, etc.

002.55 MECHANICAL ENGINEER, STRUCTURAL specialises in designing, constructing, installing and maintaining of chimneys, locomotives, rigs, water tanks, weigh bridges, etc.

002.60 MECHANICAL ENGINEER, AIR CONDITIONING designs, instals and maintains air conditioning, refrigerating or ventilating plants and accessories in buildings, mills, storage rooms, mines, etc., for obtaining and maintaining required degree of temperature or for exhaust and supply of fresh air.

002.80 MECHANICAL ENGINEERS, OTHER specialise in designing, manufacturing installing and repairing of machines and equipment and include those specialists not elsewhere classified.

003 ELECTRICAL ENGINEERS

Workers in this family design, manufacture, instal, operate and maintain electrical and electronic machines and equipment and specialise in any particular field such as power generation and transmission, telegraph and telephone systems, broadcasting and television, accoustics and audio systems, etc.

003.10 DESIGNER, ELECTRICAL ENGINEERING prepares designs of electrical plants and equipment for manufacture. Studies performance and makes alterations as required.

003.20 ELECTRICAL ENGINEER instals, operates and maintains power generating stations and transmission and distribution systems and supervises manufacture and repair of electrical machinery and equipment according to design prepared by Designer (003.10) or by himself. May be designated as GENERATION ENGINEER, DISTRIBUTION ENGINEER, OPERATION ENGINEER, etc., according to nature of work performed.

003.30 TELE-COMMUNICATION ENGINEER, GENERAL designs, manufacture, instals, operates and maintains broadcasting, television, telegraph and telephone systems, radios, radar and special microwave instruments and other tele-communication equipment.

003.35 RADIO ENGINEER, TELE-COMMUNICATION specialises in designing, constructing, installing and maintaining of broadcasting, transmission, reception and television machinery and equipment.

003.40 SOUND ENGINEER designs, plans and supervises construction, installation, operation and maintenance of accoustics and audio systems, including architectural designs of studios and halls.

003.45 MICROWAVE ENGINEER, TELE-COMMUNICATION specialises in designing, installing, maintaining and operating special microwave instruments.

003.50 LINE COMMUNICATION ENGINEER, TELE-COMMUNICATION specialises in designing, constructing, installing, operating and maintaining of telegraph and telephone equipment.

003.55 CONTROL ENGINEER, TELE-COMMUNICATION specialises in designing and maintaining of serro-mechanism and tele-system controls.

003.80 ELECTRICAL ENGINEERS, OTHER specialise in designing, manufacturing, installing and maintaining of electrical and electronic machines and equipment and include those specialists not elsewhere classified.

004 CHEMICAL ENGINEERS

Workers in this family design and instal chemical plants and equipment, develop production techniques and specialise in particular fields such as drugs and acids, petroleum, paints and varnish, fertilisers, etc.

004.10 DESIGNER, CHEMICAL ENGINEERING designs and instals chemical plants and equipment for manufacture of heavy and fine chemicals, paper pulps, cement, rayon, oils, soaps, coke, coke oven by-products, etc. May conduct research for improving quality, production, purity, etc.

004.20 CHEMICAL ENGINEER, GENERAL: Process Engineer, Chemical Engineering, directs and supervises operations of chemical plants and equipment such as dissolving filtration, evaporation, dehydration, reduction, concentration, combination, crystallization, etc., for manufacture of heavy chemicals, fine chemicals, etc., according to specifications. Records observations and adjusts factors to ensure required performance. May make simple designs and suggest alterations to get better results.

004.25 CHEMICAL ENGINEER, PAINTS AND VARNISH specialises in manufacturing paints and varnish by various chemical processes and develops improved manufacturing techniques. May be designated as CHEMICAL ENGINEER, DYES if engaged in manufacturing dyes.

004.30 CHEMICAL ENGINEER, DRUGS AND ACIDS specialises in manufacturing drugs and acids according to prescribed formulae, and develops methods for efficient production.

004.35 CHEMICAL ENGINEER, PETROLEUM specialises in developing improved techniques for treating and refining petroleum and extracting by-products by various chemical processes. Designs and instals furnaces, separators, plants and equipment and records performance. Ensures output, etc., and makes modifications to plant, equipment and processes when necessary.

004.40 CHEMICAL ENGINEER, FERTILIZERS specialises in manufacture of fertilizers and utilizations of by-products and directs manufacturing methods to ensure efficient production.

004.80 CHEMICAL ENGINEERS, OTHER specialise in designing and installing chemical plants, in developing techniques of production and in manufacturing bricks, pottery, glassware, etc., and include those specialists not elsewhere classified.

005 METALLURGICAL ENGINEERS

Workers in this family develop techniques for extracting metals from ores, investigate their physical properties and evolve processes for their treatment.

005.10 METALLURGIST, EXTRACTIVE develops improved techniques for extracting metals from ores. May specialise in ferrous, non-ferrous or any particular metal.

005.20 METALLURGIST, PHYSICAL studies physical properties, presence of impurities, structure, etc., of metals, supervise production of basic metals and alloys and develops heat-treating and rolling processes.

006 MINING ENGINEERS

Workers in this family plan, organise and supervise mining operations and specialise in extraction of metals, non-metals, petroleum, etc.

006.10 MINING ENGINEER, GENERAL determines size slope, etc., of mines of selected sites, decides suitable mining methods, prepares development and working plans, supervises extraction and ensures compliances of safety rules and prescribes rescue measures.

006.15 MINING ENGINEER, METALS specialises in conducting preliminary surveys, examining deposits and preparing working and development plans for extraction of ores. Coordinates various surveying and mining operations and supervises extraction and preliminary treating of ores. Ensures compliance of safety rules and takes precautionary and rescue measures.

006.20 MINING ENGINEER, NON-METALS specialises in examining deposits and deciding working and development plans for mining and quarrying of non-metals such as coal, mica, precious stones, granite, etc. Coordinates various surveying, mining and quarrying operations and supervises extraction and preliminary processing of deposits. Ensures compliance of safety rules and takes precautionary and rescue measures.

006.25 ENGINEER, PETROLEUM AND NATURAL GAS specialises in preparing working and development plans for extracting petroleum and natural gases. Directs and supervises drilling operations, extraction of petroleum and natural gases and their transportation to refinery.

007 SURVEYORS

Workers in this family supervise and conduct various types of land and water surveys and prepare topographical maps and other records for different purposes.

007.10 SURVEYOR, TOPOGRAPHICAL surveys land to broadly determine outlines, contours and relative position of control points (landmarks) on tract of land, coast, harbour, etc., for preparing topographical and other maps and records. May specialise in aerial surveying, tide and surveying, etc.

007.15 SURVEYOR, MINE surveys mines and prepares maps indicating location, topographical and underground features used for preparing working plans, calculating volumes of deposits, driving shafts, connecting passages, further extension, etc. Works both on surface and underground.

007.20 SURVEYOR, MARINE surveys areas of water and prepares maps indicating shore lines, depths and other underwater features for determining navigability, constructing piers and lighthouses, etc.

007.30 PLANE TABLER: Ground Surveyor prepares topographical maps based on control points fixed by Surveyor, Topographical (007.10) by plane tabling methods for various purposes such as development of area, marking boundaries, construction work, etc. Is designated as CHAIN SURVEYOR, OFF SETTER, TRAIN-GULATOR, according to methods and type of work done.

007.35 LEVELLER determines elevation and slope of ground using different types of level instruments such as dumpy level, wye level, tilting level, etc., for engineering projects.

007.40 TRAVERSER observes and records angular and linear measurements and sun-azimaths using vernier type theodolite for large scale drawings and civil engineering maps.

007.80 SURVEYORS, OTHER include all other surveyors such as those engaged in aerial survey, finding out latitudes, longitudes, areas and other details on earth's surface from available data, etc., not elsewhere classified.

009 ARCHITECTS, ENGINEERS AND SURVEYORS, n.e.c.

Workers in this family develop techniques for manufacture or treatment of oils and soaps, leather, textile, vegetable fibres, rubber, glass, sugar, alcohol, foodstuffs, wood, etc., plan construction and production work of factories, determine operational methods, conduct time and motion studies, estimate production costs, check raw materials and products to ensure conformity to specifications, design tests and direct repairs of precision instruments and include Architects, Engineers and Surveyors, not elsewhere classified.

009.05 OIL TECHNOLOGIST conducts research for developing processes for manufacturing oil, soap, vanaspati, etc. Examines physical and chemical properties of raw materials such as seeds, oils, resins, etc., and directs operations for manufacture of products to required specifications. Tests samples at different stages of production to ensure conformity to standards.

009.08. FOOD TECHNOLOGISTS guides processing, canning and dehydration of foodstuffs, examines foodstuffs for contamination, adulteration, food value and suitability for human consumption and evolves measures to protect foodstuffs from spoilage and damage during transit and storage.

009.11 SUGAR TECHNOLOGIST conducts research for developing improved methods for manufacturing sugar, power alcohol, etc. Studies physical and chemical properties of sugarcane juice and directs operations for manufacture of sugar, confectionery and by-products such as power alcohol, yeast, etc.

009.14 ALCOHOL TECHNOLOGIST conducts research for manufacturing industrial and beverage alcohols, rectified spirits and by-products such as food yeast, fusel oil, etc., and directs setting up of equipment and production distillation. Analyses raw materials such as molasses, grains, etc., investigates new micro-organisms, recommends new application of alcohol products and suitable denaturants for alcohol.

009.17 TEXTILES TECHNOLOGIST conducts research for developing improved techniques for treatment and manufacture of textile fabrics. Tests physical and chemical properties of raw materials such as cotton. silk, wool, rayon and nylon fibres, dyes, resins, bleaching agents, etc., and directs production processes involved in spinning, sizing, weaving, knitting, etc. Examines finished goods for strength, uniformity, permeability, creases, etc., to ensure quality. Evolves measures to achieve specified output at minimum cost.

009.20 FIBRE TECHNOLOGIST conducts research in extraction and utilisation of vegetable fibres such as jute, moonj, ganja, etc., and develops techniques for spinning and weaving of fibres for making utility goods and for pulping fibre for making paper, cardboard and allied materials. May find substitutes for rare fibres and detect adulteration by chemical and microscopic examination.

009.23 RUBBER TECHNOLOGIST develops production processes for manufacturing rubber products such as tyres, tubes, sports goods, rubber gloves and hot bags. Tests physical and chemical properties of raw materials such as crude rubber, antioxidents, filters, oils, waxes, colours, etc., and determines and controls production processes. Examines products for strength, flexibility, resistance, etc., and ensures conformity to prescribed standards.

009.26 LEATHER TECHNOLOGIST conducts research for developing tanning processes for manufacturing leather conforming to prescribed standards. Examines hides and skins for structural defects and tests tanning materials, such as salts, dyes, pigments, chromium compounds, etc. Directs and controls various tanning processes for manufacture of leather of desired quality and specification.

009.29 GLASS TECHNOLOGIST analyses raw materials and directs and controls operations for manufacture of glass and glass products. Conducts research to develop new formulae for improving quality of glass.

009.32 FUEL TECHNOLOGIST analyses physical and chemical properties of fuels (coal, gas, etc.) and develops improved techniques for optimum utilisation of their heating capacity. May suggest modifications in manufacturing process and furnace design and develop new fuels for specific purpose or economic value.

009.35 WOOD TECHNOLOGIST studies problems relating to seasoning, preservation and utilization of timber and its by-products, evolves and directs measures for dealing with those problems, and devises methods for converting wood into charcoal, veneers, plywoods, etc.

009.50 PLANNING ENGINEER: *Development Engineer* plans construction or production work, prepares schedules for completion or progress of work, issues work orders to departments concerned, removes difficulties in executing work and ensures compliance of time targets.

009.53 ESTIMATOR, ENGINEERING estimates materials, labour and overhead costs for production work in factory, plant or engineering works.

009.56 METHODS ENGINEER determines process, operation methods, machines, tools, cost, etc., in factory, plant or engineering works for efficient production.

009.59 INDUSTRIAL ENGINEER decides layout, machines, equipment, etc., for industrial establishment, checks production methods, costs, etc., and effects necessary improvements to ensure overall efficiency of establishments.

009.62 WORKS INSPECTOR, ENGINEERING tests raw materials and checks products in factory, plant or engineering works using gauges, micrometer, vernier, metres, testing machines, etc., to ensure that raw materials and products conform to specifications. Is designated as BOILER INSPECTOR if engaged in inspecting boilers or production of boilers.

009.65 INSTRUMENT ENGINEER designs, tests and directs repairs of all types of metres and pecision instruments. May specialise in particular type of metres or instruments.

009.68 SAFETY ENGINEER inspects plants, machines, chimneys, stoves, gangways, lighting, etc., in industrial establishment and enforces or suggests safety measures to minimise hazards and avoid accidents.

009.72 TIME AND MOTION STUDY ENGINEER studies time and motion involved in production work, better methods of work in factory, plant or engineering works and formulates methods for improving working efficiency.

09 DRAUGHTSMEN AND SCIENCE AND ENGINEERING TECHNICIANS, n.c.c.

Workers in this group prepare drawings for engineering works and draw political, physical and other maps, set or assist in setting apparatus in laboratories, conduct routine tests and perform other related functions of routine technical nature.

090 DRAUGHTSMEN

Workers in this family prepare drawings from sketches, designs and notes for various civil, mechanical and electrical engineering works and draw political, physical, geological and other maps.

090.10 DRAUGHTSMAN, ARCHITECTURAL prepares drawings of buildings, parks, gardens, monuments, etc, from sketches, designs or data for purposes of construction.

090.15 DRAUGHTSMAN, CIVIL prepares drawings of buildings, highways, dams, etc., from sketches, notes or data for purposes of construction or alteration.

090.25 DRAUGHTSMAN, MECHANICAL prepares drawings of machines, plants, mechanical components, equipments, etc., from sketches, notes, data or sample for purposes of manufacture or repairs. Draws sectional views, mentions tolerances and gives other details for machining, fitting, assembly and finishing operations.

090.35 DRAUGHTSMAN, STRUCTURAL prepares drawings of bridges, steel structures, roof trusses, etc., from sketches, designs or data for purposes of construction or repairs.

090.45 DRAUGHTSMAN, ELECTRICAL prepares drawings of wirings, motors, generators and other electrical goods from sketches, designs or data for purposes of manufacture, installation or repairs.

090.60 CARTOGRAPHER prepares political, physical, economic, geological or other maps from aerial photographs, data, etc., showing contours, topography, location and other details, for purposes of administration, scientific research, construction, well drilling, etc.

091 LABORATORY ASSISTANTS

Workers in this family arrange and set apparatus and other equipment in various types of laboratories, conduct tests of routine nature and generally assist in carrying out studies and experiments.

091.10 LABORATORY ASSISTANT, PHYSICAL arranges and sets various instruments and appliances such as magnets, galvanometers, mirrors, lights, compressors, exhaust pump, batteries, etc., for conducting experiments in physical laboratory, records routine observations and assists Physicists (012.10 and 012.15...) in carrying out various studies and experiments.

091.15 LABORATORY ASSISTANT, CHEMICAL arranges and sets apparatus, chemicals and other equipment for carrying out experiments in chemical laboratory, conducts routine tests such as filtration, precipitation, etc., and assists Chemists (010.10 and 010.15 . . .) in his work.

091.20 LABORATORY ASSISTANT, PHARMACEUTICAL sets apparatus and other equipment in pharmaceutical laboratory, conducts routine tests of various ingredients for manufacture of drugs and medicines and assists Pharmaceutical Chemist (011.10) in carrying out studies and experiments.

091.25 LABORATORY ASSISTANT, FOOD AND BEVERAGES conducts routine tests of food, drinks and other edibles in laboratory to determine their properties, nutritional value, alcoholic content, etc., and whether they conform to prescribed standards or have been adulterated.

091.30 LABORATORY ASSISTANT, BOTANICAL arranges microscopes, dissecting table, instruments, etc., in botanical laboratory. Conducts routine tests for purposes of classification and analysis, preserves botanical specimens.

091.35 LABORATORY ASSISTANT, ZOOLOGICAL arranges microscopes, dissecting table, instruments, etc., in zoological laboratory, performs routine tests for purposes of classification, analysis, etc., and preserves zoological specimens.

091.40 LABORATORY ASSISTANT, CLINICAL sets apparatus and conducts routine tests of blood, urine, sputum, etc., in clinical laboratory, for medical purposes such as diagnosis of diseases, determination of blood groups, etc.

091.45 LABORATORY ASSISTANT, GEOLOGICAL sets equipment in geological laboratory for carrying out various studies conducts routine examination of mineral samples, assists Geologist (224.10) in determining location, composition, crystalline structure, percentage, etc., of minerals.

091.50 LABORATORY ASSISTANT, SOIL conducts routine soil tests in laboratory for purposes of determining soil characteristics, correcting soil defects, raising fertility, etc.

091.55 LABORATORY ASSISTANT, PETROLEUM AND LUBRICANTS performs routine tests of petroleum and lubricants in laboratories to determine their physical and chemical properties and to manufacture various petroleum products such as fuels, wax, coke, bitumen, etc.

091.60 LABORATORY ASSISTANT, METALLURGICAL conducts routine examination of metals and alloys to determine their physical and chemical properties, and assists Metallurgist (013.10) to testing, experimenting and analysing different types of metals and alloys.

091.65 LABORATORY ASSISTANT, ENGINEERING fits and sets model engines, machines, metres and other equipment for conducting experiments and for demonstration in engineering laboratory, makes routine observations and records readings and keeps equipments in working order.

091.70 LABORATORY ASSISTANT, GLASS AND CERAMICS conducts routine tests of silica, clay and other ingredients in laboratory to determine their physical and chemical properties and to manufacture glass and ceramic products.

091.75 LABORATORY ASSISTANTS, OTHER arrange and set apparatus and other equipment in laboratories and perform various tests of routine nature and include those engaged in conducting laboratory tests of rubber, plastics, cosmetics, salts, textiles, films, etc., not elsewhere classified.

099 SCIENCE AND ENGINEERING TECHNICIANS, n.e.c.

Workers in this family assist in setting apparatus equipment in laboratories, trace engineering designs, prepare rock slides, examine rock samples and fossils, perform other routine tasks of technical nature and include science and engineering technicians not elsewhere classified.

099.10 TRACER traces drawing of buildings, bridges, machines and other engineering designs or tracing cloth or paper or ink and prepares blueprint for purposes of construction, manufacture or record.

099.20 LABORATORY ATTENDANT keeps laboratory equipment tidy, assists Laboratory Assistants (091) in preparing standard solutions and reagents and setting apparatus and equipment for conducting various tests and performs other related tasks of routine nature.

099.30 ROCK SLICER slices rock and prepares microscopic slides of heavy mineral grains for study and analysis.

099.40 SLIDE EXAMINER, PETROLOGY examines rock samples under petrogrophic microscope, identifies and calculates percentage of mineral present in samples and prepares charts, tables, etc., showing stratigraphical and lithological data.

099.50 SLIDE EXAMINER, PALAENTOLOGY collects rock samples and fossils, examines rock samples under microscope and records their lithological and other characteristics, studies fossil characteristics and maintains rock slides, fossils and records of analytical data.

099.80 SCIENCE AND ENGINEERING TECHNICIANS, OTHER perform various routine technical tasks in laboratory or field connected with setting apparatus, conducting tests, making observations and include those not elsewhere classified.

APPENDIX II

Activity Analysis of Technicians in Machine Tool Industry

1. *Inspection*
   - 1.1 Inspecting the first piece after manufacture. Guiding the operator in cases of deviations in the piece. Inspection of the complete dimensions of all the pieces after completion of job.

     Knowledge of all measuring instruments, fits, tolerances, etc., are essential. Must have enough knowledge of the functional aspects of the components to take decisions on components which deviate slightly from the drawing and accepted standards.
   - 1.2 Inspection of pre, group, sub and final assemblies of the various products assembled.
   - 1.3 Inspection of gauges manufactured in the factory.
   - 1.4 Conducting running tests of completed machines on the test floor. Controlling the final quality of the machines. Tool setting and customer demonstration.
   - 1.5 Demonstration of machines in Showrooms, Trade and Industries Fairs, Exhibitions.
   - 1.6 Periodical inspection and correction of all gauges and measuring instruments used in the factory.

2. *Shop Supervision*
   - 2.1 Guiding the workmen under them from the time of allotting the work to them till completion of job, through the various stages, viz., reading of drawing, job set up, first piece inspection, etc.
   - 2.2 Supervision of workmen and maintenance of industrial discipline.
   - 2.3 Arranging the work load and scheduling of various operations in keeping with the targets laid down by management.
   - 2.4 Controlling of absenteeism, efficiency, idle times, etc.
   - 2.5 Keeping the higher officers posted regarding all developments.
   - 2.6 Welfare of workmen.

3. *Production Control*
   - 3.1 Collection of all manufacturing documents, drawings, layouts, etc., and supplying to the shops (including Assembly, Foundry, etc.)
   - 3.2 Arranging for cutting of materials to specifications and supplying the materials to shops.
   - 3.3 Loading the operations on shops on prefixed priorities and schedules.
   - 3.4. Working out priorities and schedules as per targets laid down.
   - 3.5 Arranging for movement of components between operations wherever necessary, between sections, inspection of pieces, etc.
   - 3.6 Maintaining the progress of all components under their control operation by operation.
   - 3.7 Re-arranging priorities and rescheduling of jobs conforming with changes in production programmes, etc.
   - 3.8 Keep management informed of critical shortages, etc., in time so as to take corrective action.

4. *Methods Engineering*
   - 4.1 Deciding which of the components required for the various products are to be manufactured, off loaded on other sources, or to be bought, etc.
   - 4.2 Laying down the method of manufacture of all parts

decided to be manufactured in the factory taking into account the resources available.

4.3 Deciding the special tools, jigs, fixtures, etc., required for the manufacture of the various components.

4.4 Releasing orders for the manufacture of patterns required for the manufacture of castings in Foundry.

4.5 Conducting time studies, creating elemental time standard tables for set up, handling, etc.

4.6 Laying down standards for the speeds, feeds, etc., to be used on the various machines.

4.7 Calculating the time (set up time, operation time, etc.) for each operation of every component based on standards or fresh time studies, etc., giving due weightage to the workshop allowances, personal allowances, etc.

4.8 Working out the material, labour and other cost estimates for jobs undertaken for outside customers.

4.9 Looking after the staff connected with the Time Recording of the various jobs done in the factory.

4.10 Reviewing the estimates in the light of the actual times taken.

4.11 Maintain various records connected with the day to day operation of jobs, scrutinising them and routing them to computer centre for further processing.

4.12 Maintain liaison with shops in regard to their day to day problems.

4.13 Conduct sampling studies whenever required.

4.14 Changing layouts, work simplification, tool engineering, etc.

5. *Tool Design*

5.1 Design of all special tools, jigs and fixtures as indicated by the Methods Engineering section.

5.2 Complete tooling up of machines to Customer Specifications.

6. *Material Engineering*

6.1 Arranging for the procurement of all types of materials taking into account the lead time required for imported, indigenous materials, etc., so as to get the materials in time.

6.2 Sub-contracting the complete or partial manufacture of components as indicated by Methods Engineering and follow up.
6.3 Complete operation and control of the work orders system used in the factory.
6.4 Initiating and releasing the necessary orders for the manufacture and assembly of various products every month.
6.5 Initiating the release of manufacture of certain components.
6.6 Complete operation and maintenance of all the various stores, viz., Finished parts store, Main store, and General stores consisting of stationery stores, fire-proof stores, etc.
6.7 Receiving of all the materials coming into the factory and arranging for their inspection and despatch to various stores.
6.8 Issue of materials to various sections as per system prevalent.
6.9 Maintenance of stock and control.
6.10 Initiating release of necessary orders for purchase of certain items, based on minimum, etc.
6.11 Operating the selective inventory control system.

7. *Maintenance*
7.1 Civil, Electrical and Mechanical maintenance of all buildings, machines, service equipment, etc., within the factory.
7.2 Preventive maintenance of all machines and equipment as per prefixed schedules.
7.3 Operation and maintenance of all material handling equipment.
7.4 Sanitation and housekeeping.
7.5 Reconditioning of machines and equipment.
7.6 Organising Industrial Safety.

8. *Training Centre*
8.1 Theory and practical aspects of the various basic trades like fitting, turning, milling, grinding, etc.
8.2 Workshop theory, drawing, etc.

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